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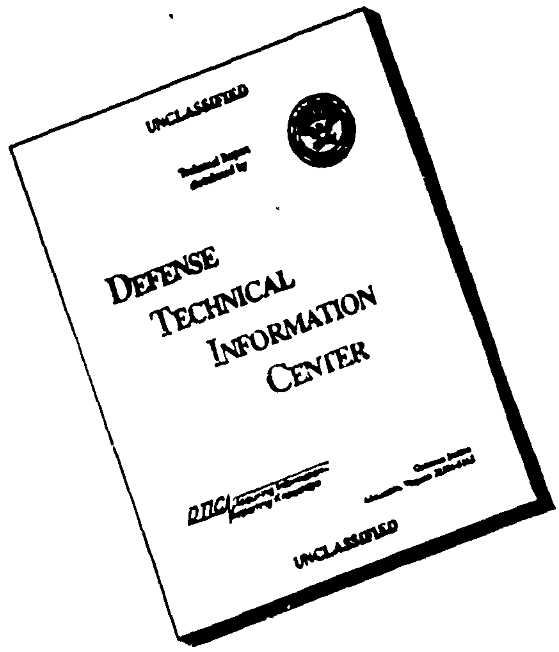

AFMDC-TR-60-16

AFMDC-TR-60-16

AIR FORCE MISSILE DEVELOPMENT CENTER

TECHNICAL REPORT

MANHIGH III

USAF MANNED BALLOON FLIGHT INTO THE STRATOSPHERE

as reported by

Pilot and Task Scientist

HOLLOMAN AIR FORCE BASE
NEW MEXICO

April 1961

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USAF MANNED BALLOON FLIGHT INTO THE STRATOSPHERE

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Pilot and Task Scientists

Aeromedical Field Laboratory
Directorate of Advanced Technology

AIR FORCE MISSILE DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
Holloman Air Force Base, New Mexico

April 1961

ABSTRACT

This report covers the manned balloon flight MANHIGH III, the third - and last - of a series of flights into the stratosphere directed by the Aeromedical Field Laboratory. Twelve sections, prepared by the pilot and the task scientists, describe the vehicle and its performance, selection and preparation of prospective pilots, the principal psychological and physiological parameters of the subject before, during and after the flight, the operation of a sealed environment under space equivalent conditions, cosmic radiation studies, and related problems such as pilot's nutrition.

PUBLICATION REVIEW

This Technical Report has been reviewed and is hereby approved for publication.

FOR THE COMMANDER:

Hamilton H. Blackshear

HAMILTON H. BLACKSHEAR
LtColonel, USAF, MC
Chief, Aeromedical Field Laboratory

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MANHIGH III

CHAPTER I

INTRODUCTION TO OPERATION MANHIGH III - MANNED BALLOON FLIGHT INTO THE STRATOSPHERE

The MANHIGH balloon flights into the stratosphere are to be considered as a major contribution of the United States Air Force Aeromedical Field Laboratory in the area of the performance of human operators and of the reliability of sealed systems under space equivalent conditions.

The six and one-half hour MANHIGH I flight piloted by Captain Joseph Kittinger in June 1957, established the feasibility of manned flight to 97,000 feet in the MANHIGH capsule. The thirty-two hour MANHIGH II flight piloted by Lt Colonel David G. Simons in August 1957 explored the possibility of making observations at the 100,000 foot level through a twenty-four hour period, and examined the problems man faces living under space-equivalent conditions.

The purpose of the MANHIGH III flight was to make scientific observations through the eyes of the pilot under the direction of a panel of experts in communication with him from the ground. Medically, it studied the ability of the pilot to make these observations and developed and tested techniques to assess his performance during flight.

MANHIGH I and MANHIGH II were described extensively in Technical Reports AFMDC-TR-59-24 and AFMDC-TR-59-28.

This report covers the MANHIGH III flight, the third - and the last - of the MANHIGH project.

The various chapters of this report were prepared by the individuals who were in charge of the numerous and complex tasks of this project. The reader has, therefore, the opportunity to follow the phases of the flight from different points of view. The repetitions involved in this procedure show the many difficulties encountered during the MANHIGH project, and especially during the MANHIGH III flight.

Released by authors 19 October 1960

CHAPTER II

SYSTEM DESCRIPTION AND FLIGHT PERFORMANCE

A. THE STRUCTURE OF THE CAPSULE*

1. General

The MANHIGH III flight system was very similar to MANHIGH I and II in size and shape. However, the MANHIGH III system incorporated many refinements and additional equipment.

The capsule itself was larger than the previous capsules, being three feet in diameter and nine feet high. The structure consisted of two main assemblies, the internal and the external (Fig. 1 and 2). The internal assembly included the upper dome and turret assembly and all the interior equipment. The exterior assembly included the lower pressure vessel (lower "can" with lower dome), substructure (or "crash") structure), 12-and 24-volt jettisonable batteries, and other equipment designed to operate outside the pressure vessel.

2. Interior Assembly

The upper d e was of one-piece spun aluminum, and its lower edge was a pressure flange which mated with a similar flange on the upper part of the turret ring. These two flanges were pulled into a pressure-tight seal with the upper marmon clamp (Fig. 2). This dome contained the subject camera and photo panel camera, the instrument panel, the manual decompression valve, a rack for the pilot's K-100 movie camera, a vent-ring to direct regenerated air to the portholes to prevent fogging, and a potentiometer with adjusting rheostat for the body and capsule temperature sensors (Fig. 3). The VHF antenna and the autosyn compass transmitter were attached to the outside top of the dome.

The instrument panel (Fig. 4) contained the following items: clock, voltmeter (24 volt), ammeter (24 volt), voltmeter (12 volt), ammeter (12 volt), pressure gauge (cabin to outside differential), vertical speed indicator (Air Force standard), altimeter (Air Force standard), altimeter (high altitude NACA type), cabin altitude indicator, milliammeter (low velocity thermistor), milliammeter (high velocity

* By Lt C. M. McClure

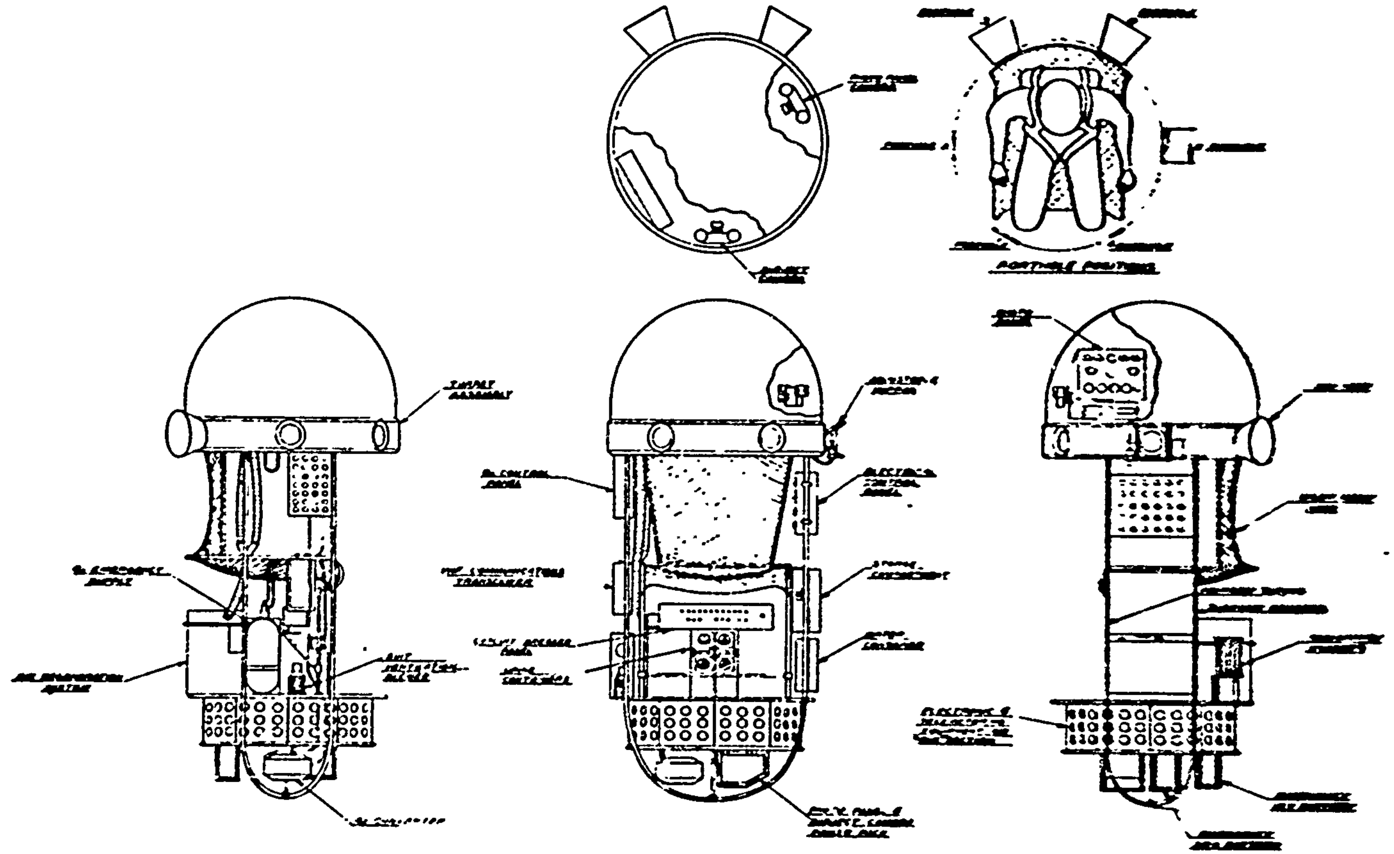


Figure 1. Internal Assembly

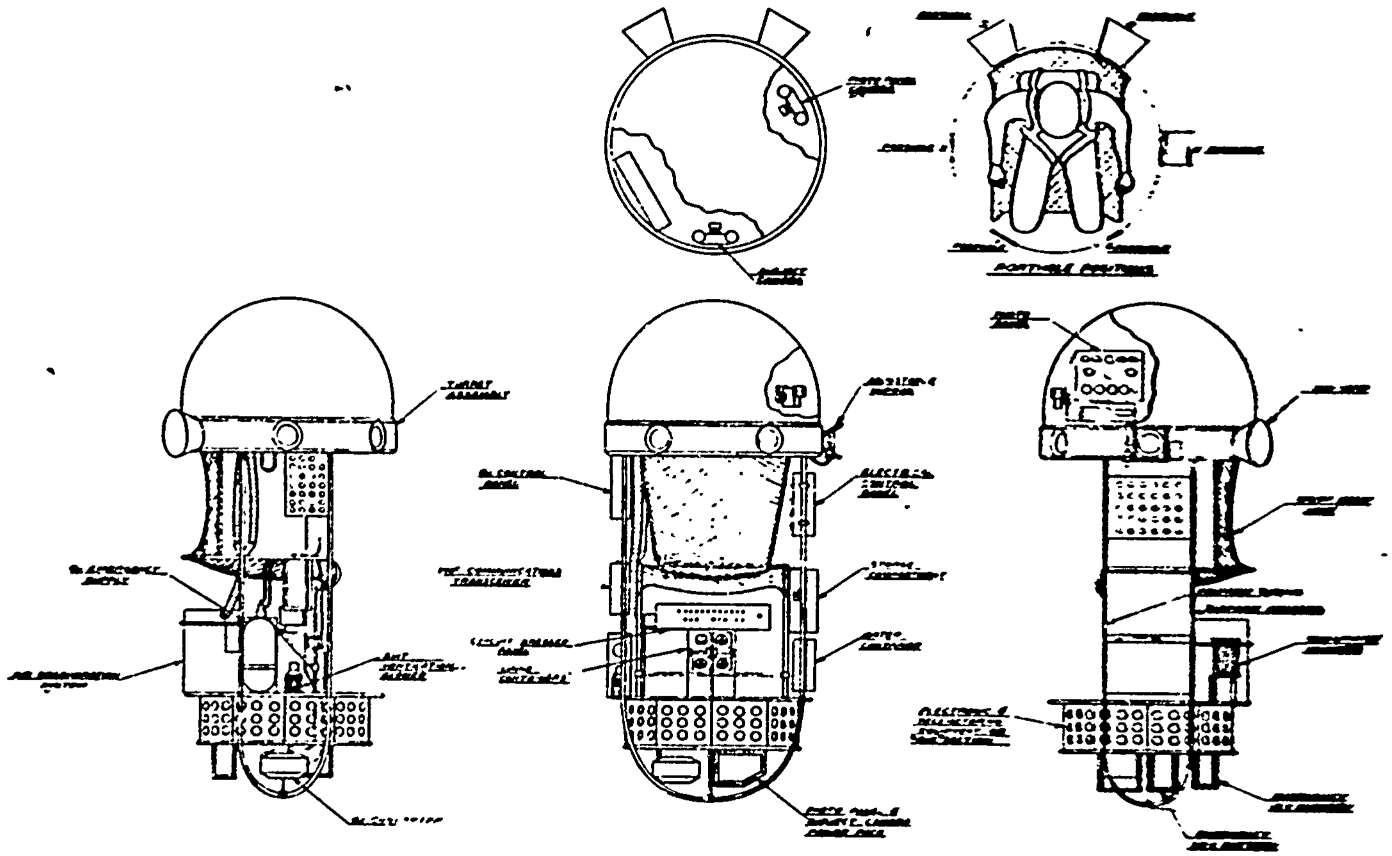


Figure 1. Internal Assembly

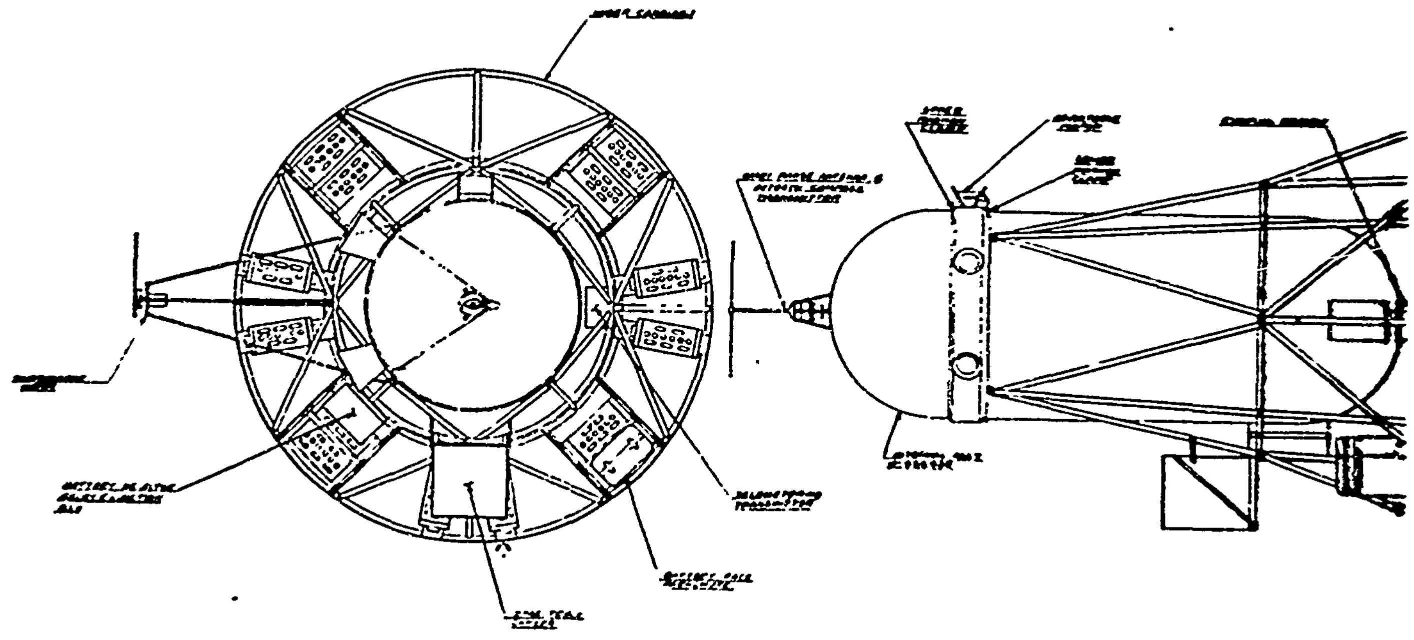


Figure 2. External Assembly

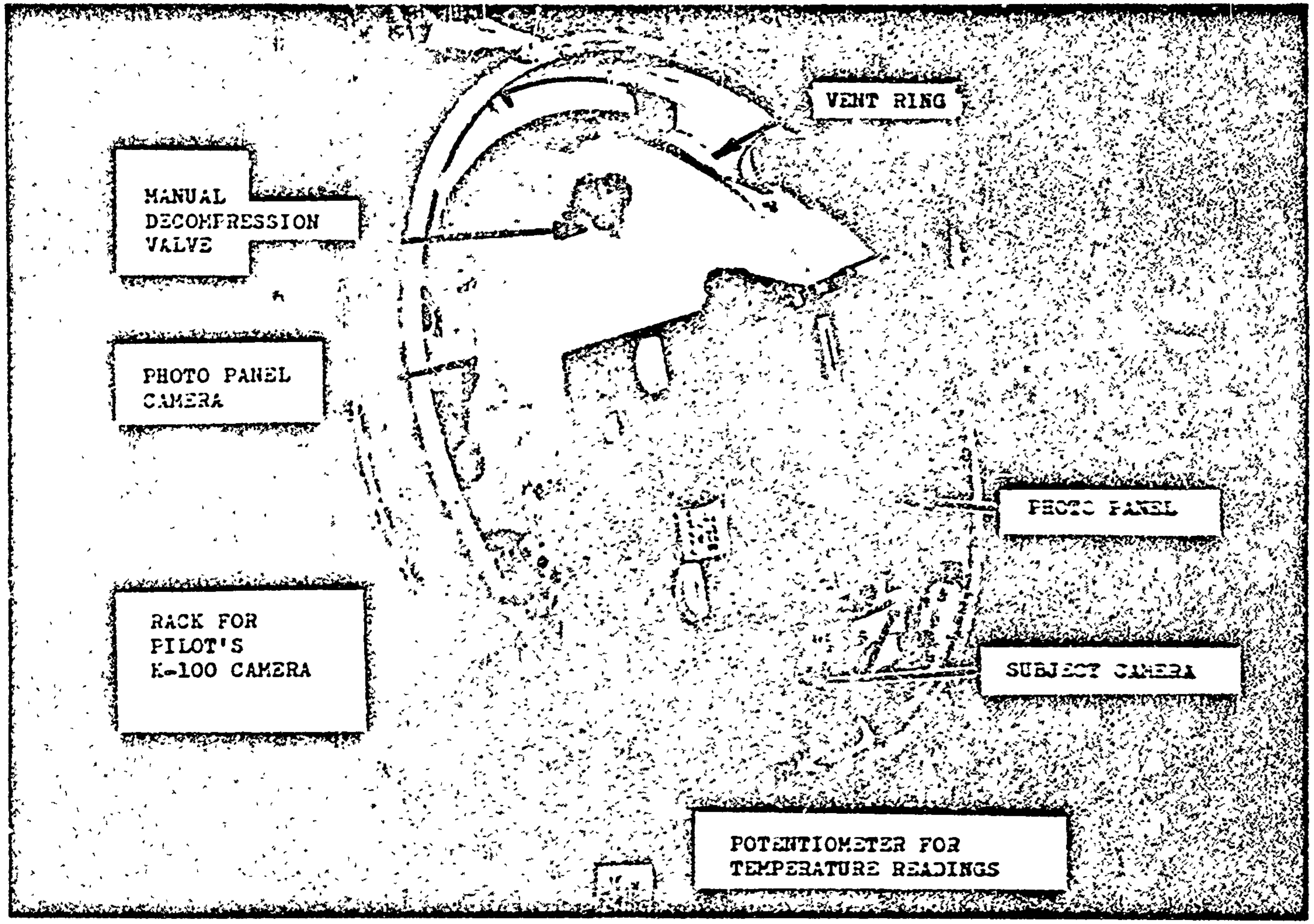


Figure 3. Upper Dome

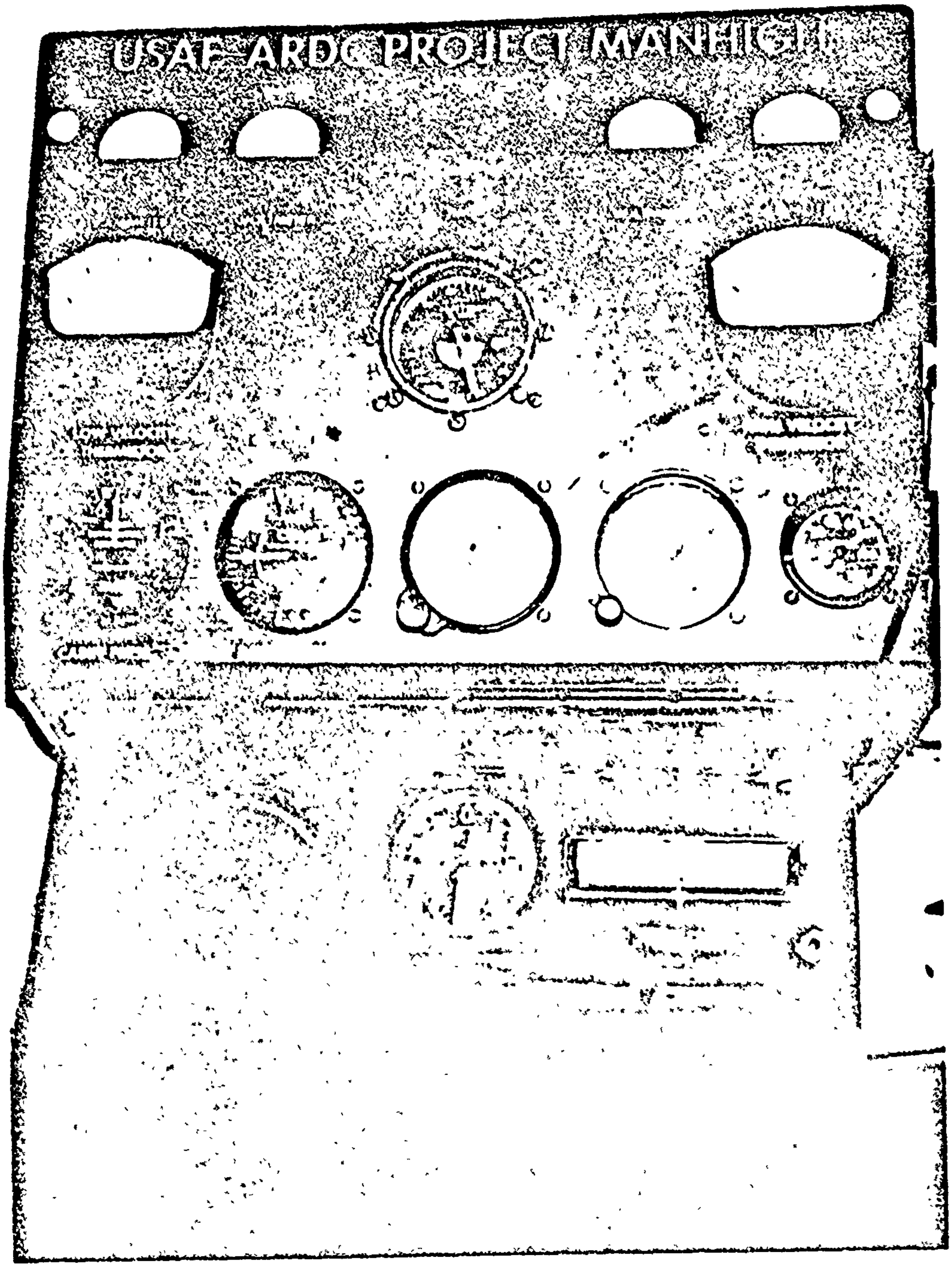


Figure 4. Instrument Panel

thermistor), autosyn compass, temperature gauge (inside temperature), relative humidity gauge, and oxygen partial-pressure indicator.

Just below the dome and on a level with the pilot's head was the machined steel ring containing the six portholes. This unit was the main structural support member of the interior-exterior assemblies and was known as the turret assembly (Fig. 1 and 2). The Firewel valve was bolted to this ring between portholes number two and three and the Firewel vent drilled and placed behind the valve. All electrical through-connections were made by installing a double pin cannon plug connector through the turret ring, connections then being made to this cannon pin on inside and outside of the turret ring. The parachute riser attach points were integrally made into the outside of the turret structure. Two plane mirrors, mounted to afford the pilot an almost vertical up and down view, were also part of the turret structure, arranged on the outside of porthole number five (Fig. 1). These mirrors could be varied slightly in angle of view, being driven by a small, reversible electric motor operable from within the capsule.

Equipment below the turret, on a level with the pilot, was not attached to the shell of the capsule as was done with items contained in the upper dome, but was secured either to the aluminum tubing framework leading vertically down from the turret or to the subfloors fastened horizontally across this tubing (Fig. 5). The general arrangement of items contained in this part of the internal assembly is shown in Figure 1. The control panel was located on the left of the pilot (Fig. 6 and 7). The items on the control panel are:

(1) 12-Volt Power Selector Switch - This switch selected any one of four alternate, ballastable exterior battery packs or one interior, non-ballastable emergency (silver cell) pack.

(2) 12-Volt Master Switch - Provided an "ON-OFF" switch for the power pack selected.

(3) Red and Green Lights - Indicated whether on emergency or normal power pack.

(4) 24-Volt Selector Switch - Same as No. 1 above.

(5) 24-Volt Master Switch - Same function as No. 2 above.

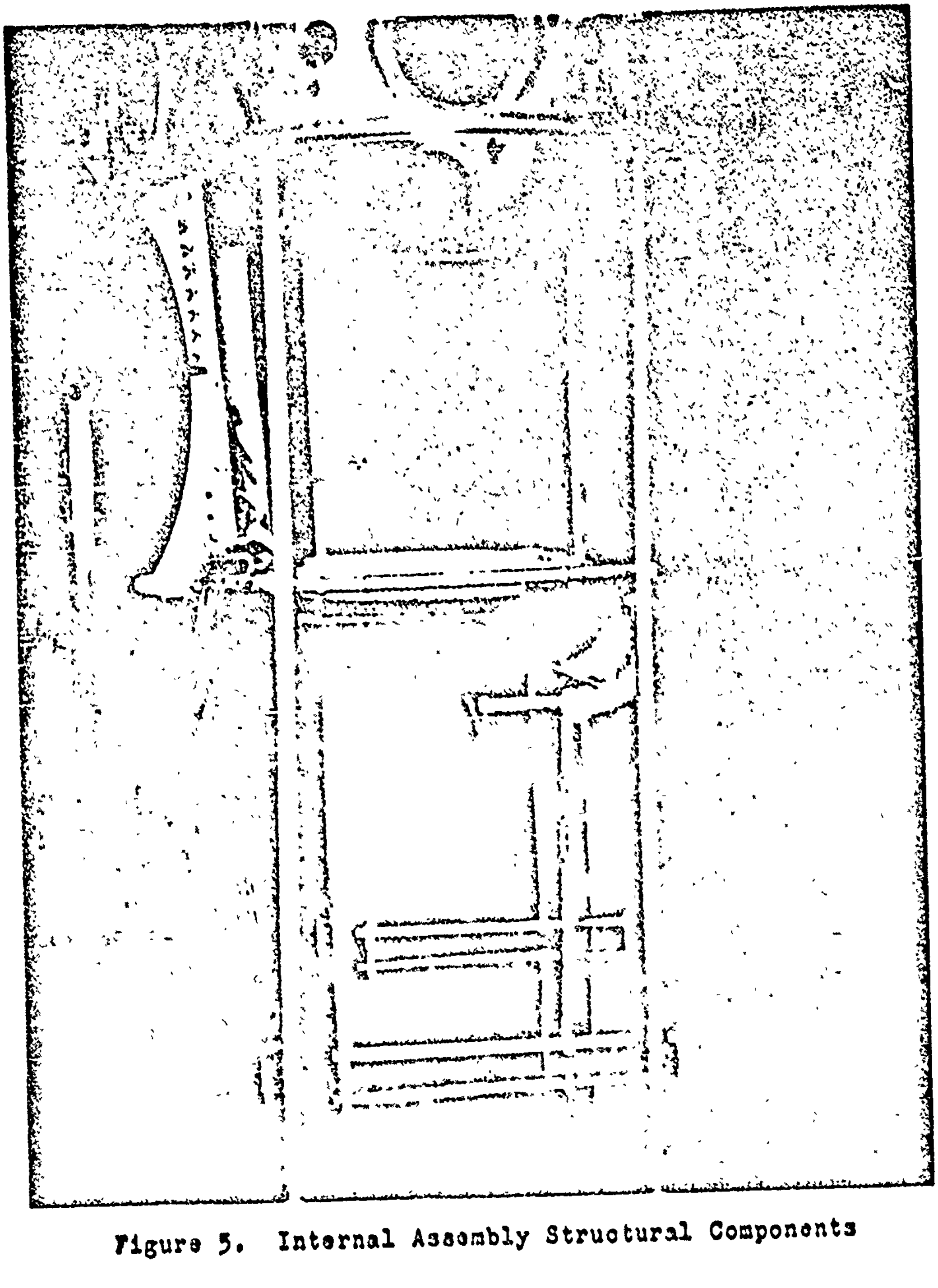


Figure 5. Internal Assembly Structural Components

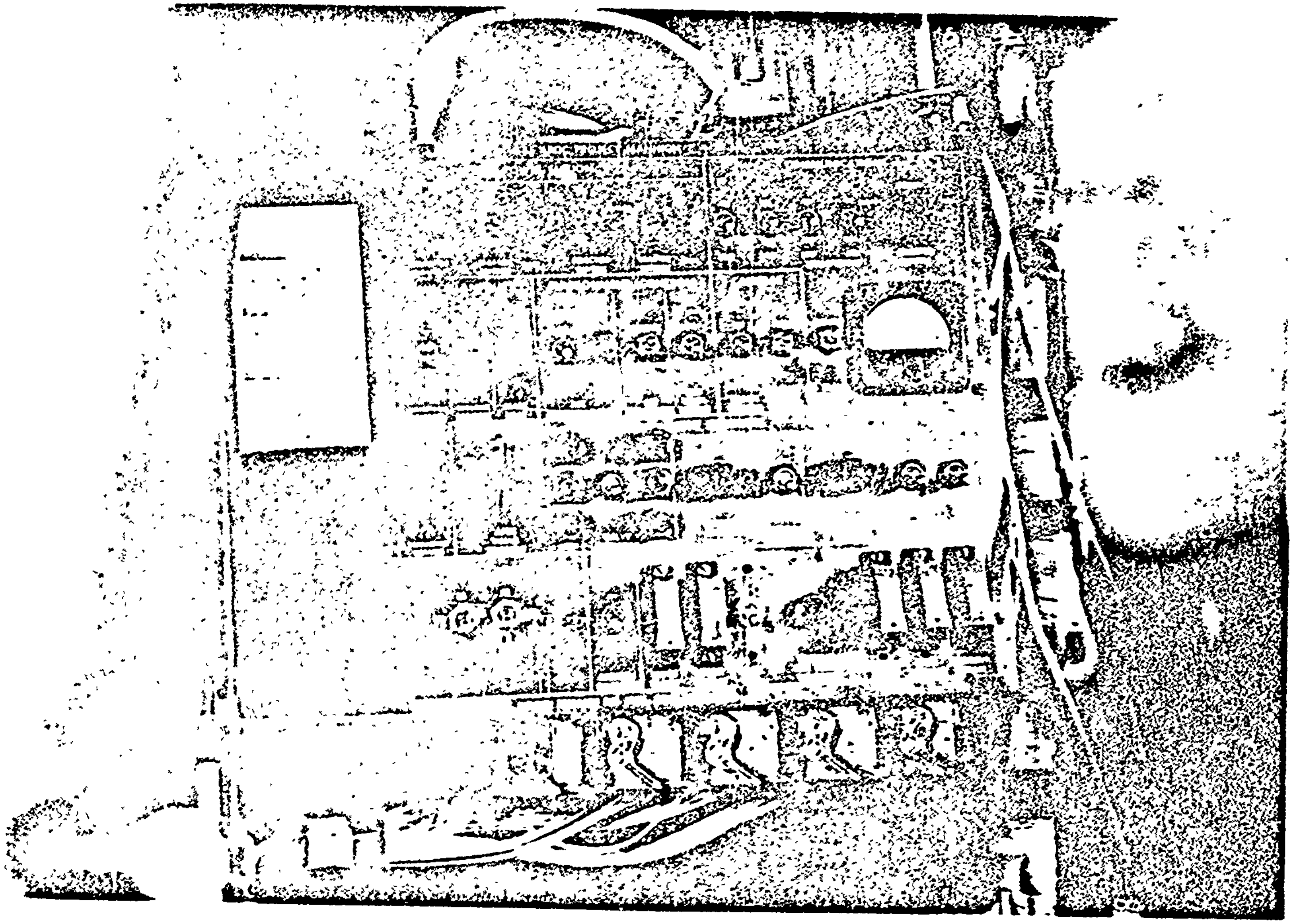


Figure 6. Control Panel

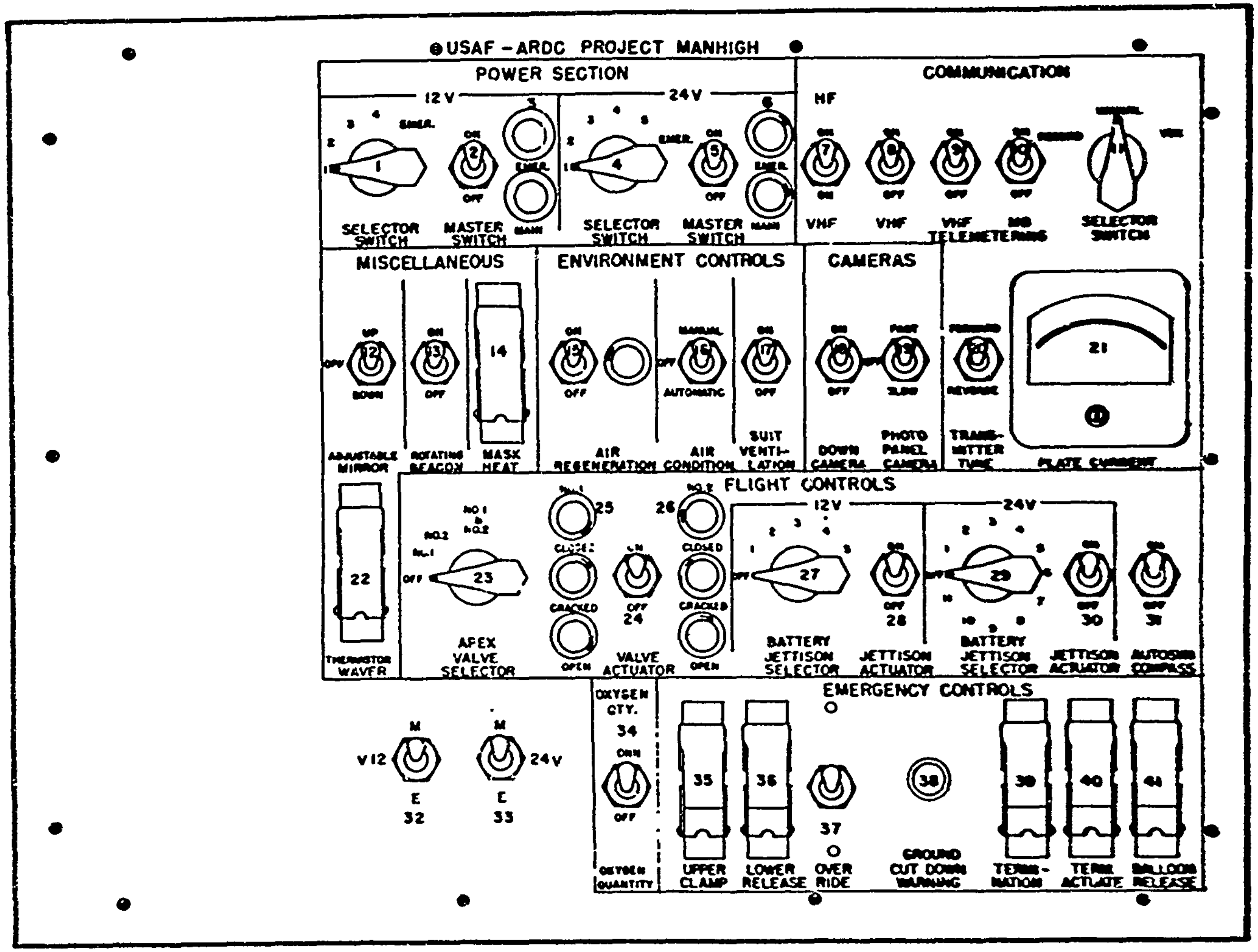


Figure 7. Control Panel (Diagram)

(6) 24-Volt Indicator Lights - Function same as No. 3.

(7) VHF or HF Selector Switch

(8) VHF "ON-OFF" Switch

(9) and (10) VHF and Marker Beacon Telemetry Switches.

(11) Selector Switch for VHF Communications - Manual use is foot switch; VOX position, a voice-operated relay.

(12) Adjustable Mirror Switch - For driving mirror up and down.

(13) Rotating Beacon "ON-OFF" Switch

(14) Mask Heat "ON-OFF" Switch

(15) Air Regenerator Blower "ON-OFF" Switch and "ON" Indicator Light

(16) Air Conditioner Switch - A heater only, installed just below the pilot's seat and near the air regenerator. This heater had "ON", "OFF", and "AUTOMATIC" positions. The automatic position made use of a preset thermostat.

(17) Suit Ventilation Switch - Removed for flight.

(18) Down Camera "ON-OFF" Switch

(19) Photo Panel Camera "FAST-SLOW" Switch - Controlled the picture rate.

(20) Transmitter Tune

(21) Plate Current Meter - Indicated plate current in HF transmitter, for tuning.

(22) Thermistor Waver "ON-OFF" Switch

(23) Apex Valve Selector Switch - Provided means to select either one or both valves simultaneously.

(24) Valve Actuator Switch - Actuated the selected valve condition.

(25) and (26) Indicator Lights for Valves - Green for fully closed, amber for partly open and red for fully open.

(27) 12-Volt Battery Jettison Selector Switch - Selected the 12-volt pack that was to be dropped as ballast.

(28) Jettison Actuator Switch

(29) 24-Volt Battery Jettison Selector Switch - Selected any one of ten separate 12-volt packs comprising the five 24-volt battery groups.

(30) 24-Volt Battery Pack Jettison Actuator

(31) Autosyn Compass Switch "ON-OFF" - Installed to be able to cut the compass off to reduce power drain.

(32) 12-Volt Master Relay Switch - Determined the 12-volt power choice for the power to the hold-down relay. Selected either normal or emergency power.

(33) 24-Volt Master Relay Switch

(34) Oxygen Quantity Gauge "ON-OFF" Switch - The oxygen level was measured only when this was in the "ON" position. Used to reduce power drain.

(35) Upper Clamp Release - Activated squib that released upper marmon clamp.

(36) Lower Clamp Release

(37) Cut-Down Override Switch - Allowed the pilot to override ground cut-down procedure.

(38) Red Light Indicating Ground Cut-Down

(39) Termination Switch - Air termination switch which must be operated simultaneously with termination actuator switch to function.

(40) Termination Actuator Switch

(41) Balloon Release Switch, or Ground Termination Switch - Must also be actuated simultaneously with termination actuator switch.

Note: All control switches labeled "Emergency Control" in the diagram are covered with a reverse operating safety cover.

Located above the control panel was the carbon dioxide analyzer, which was a Fyrite volumetric instrument of the Orsat type.

An automatic chest-type personnel parachute was placed in front of the pilot after his entrance. It was hung on two hooks from the lower part of the turret. Also hinged from the bottom of the porthole ring was the mount for the spot photometer and a "gadget-bag" containing new and exposed film, camera cassettes, photometer computer, flashlight, etc. Figure 8 shows the complete interior assembly with all gear and the pilot ready to be lowered and sealed for flight.

To the pilot's right was the oxygen system panel (Fig. 9). The capsule-suit selector switch allowed the pilot to direct the oxygen from LOX or high pressure source, either to the suit face-piece or into the capsule. Oxygen could be brought into the capsule under constant flow conditions by using the constant flow valve. The capsule emergency oxygen bottle (Fig. 10) was of the high pressure type and would provide sufficient oxygen for seven hours when used through the face-piece.

Below the control panel (Fig. 11) to the pilot's left, was a food-storage container of approximately 0.5 cubic foot. Just below this was the water container of 0.5 cubic foot capacity. Below the mesh seat at the front of the capsule were located the circuit breaker panel and four urine bottles of 1.5 quart capacity each. Toward the rear and below the seat was an auxiliary heater to be used mainly to avoid freezing of the air rogenerator unit and also for pilot comfort.

The omni or VHF transceiver set (Fig. 10) was located to the right of the pilot just below the oxygen control panel. This set had a VHF tunable receiver and two-channel crystal-controlled transmitter. It was used as the primary voice communication on 122.8 and 121.5 megacycles. It could also be used as a navigational aid by taking bearings on selected VHF ground stations.

The air regenerator (Fig. 10, 12, 13, 14 and 15) was located just below the pilot's seat to the rear, bolted to the subfloor. This unit was considerably different from those carried on the two previous MANHIGH flights. The other flights utilized this unit outboard, ducting the air from the capsule out and back. The MANHIGH III unit was inboard, with a blower picking up the capsule atmosphere directly. The chemicals previously used were discarded in favor of KOH. This

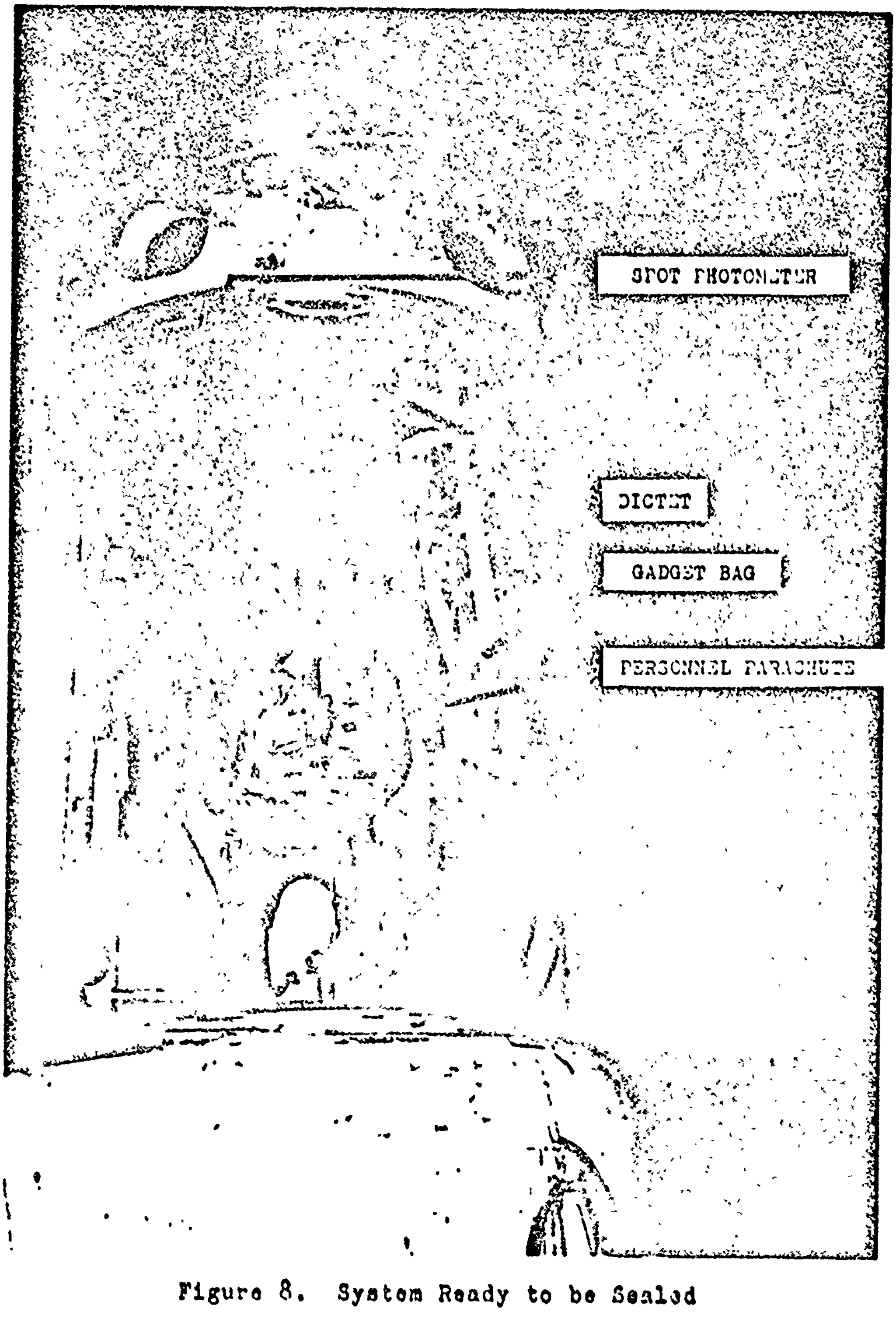


Figure 8. System Ready to be Sealed

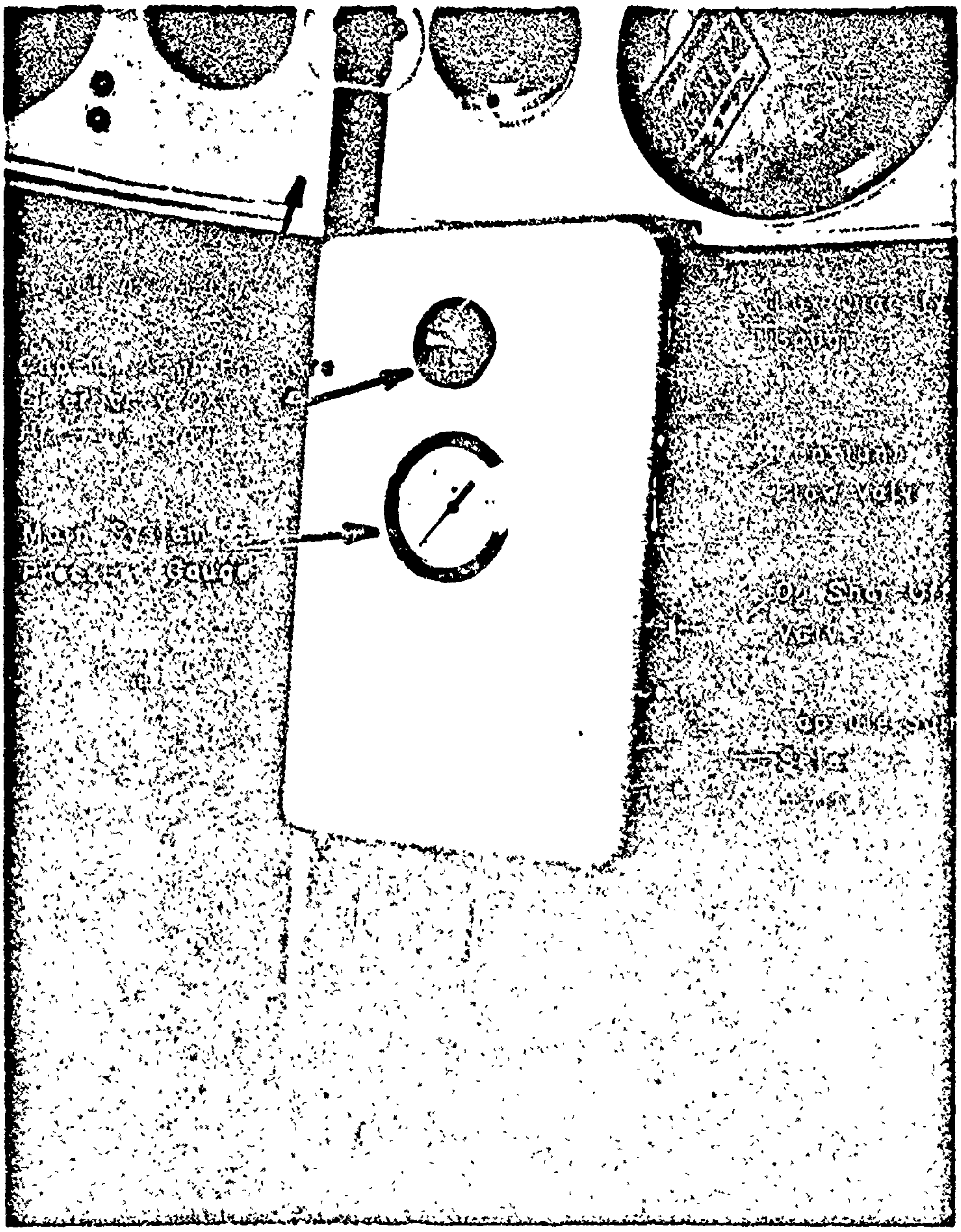


Figure 9. Oxygen System Panel

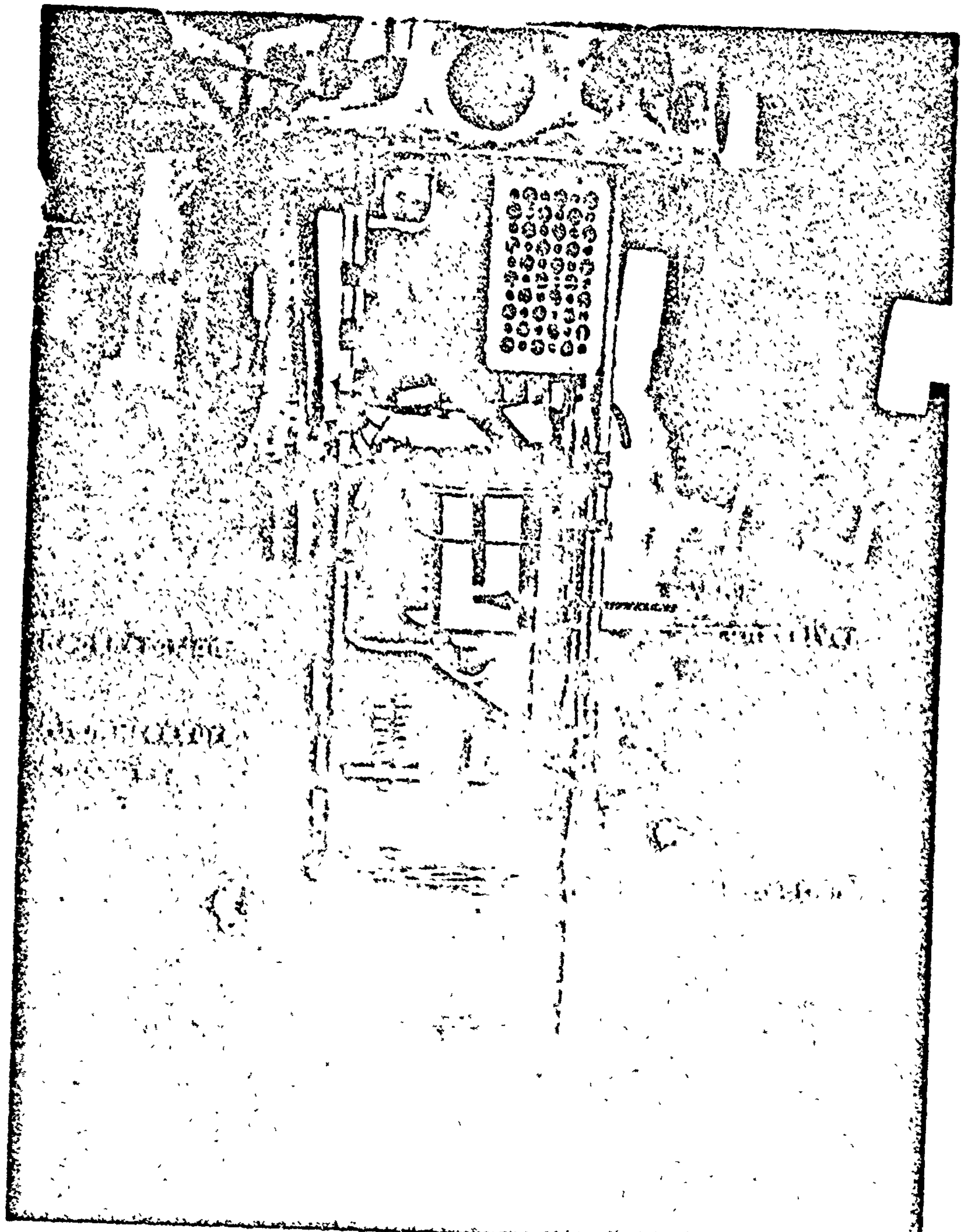


Figure 10. Right Side View Internal Assembly

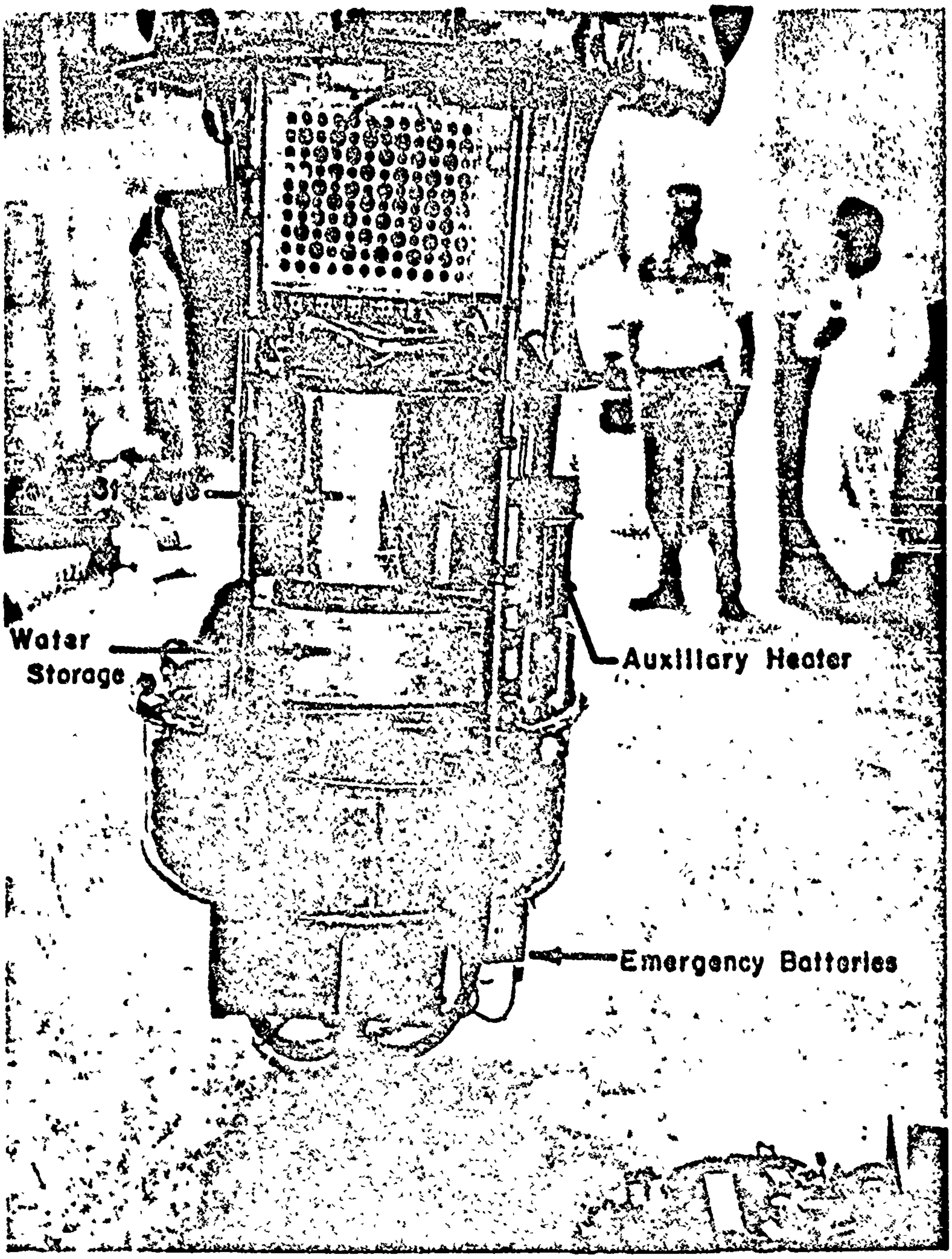


Figure 11. Left Side View Internal Assembly

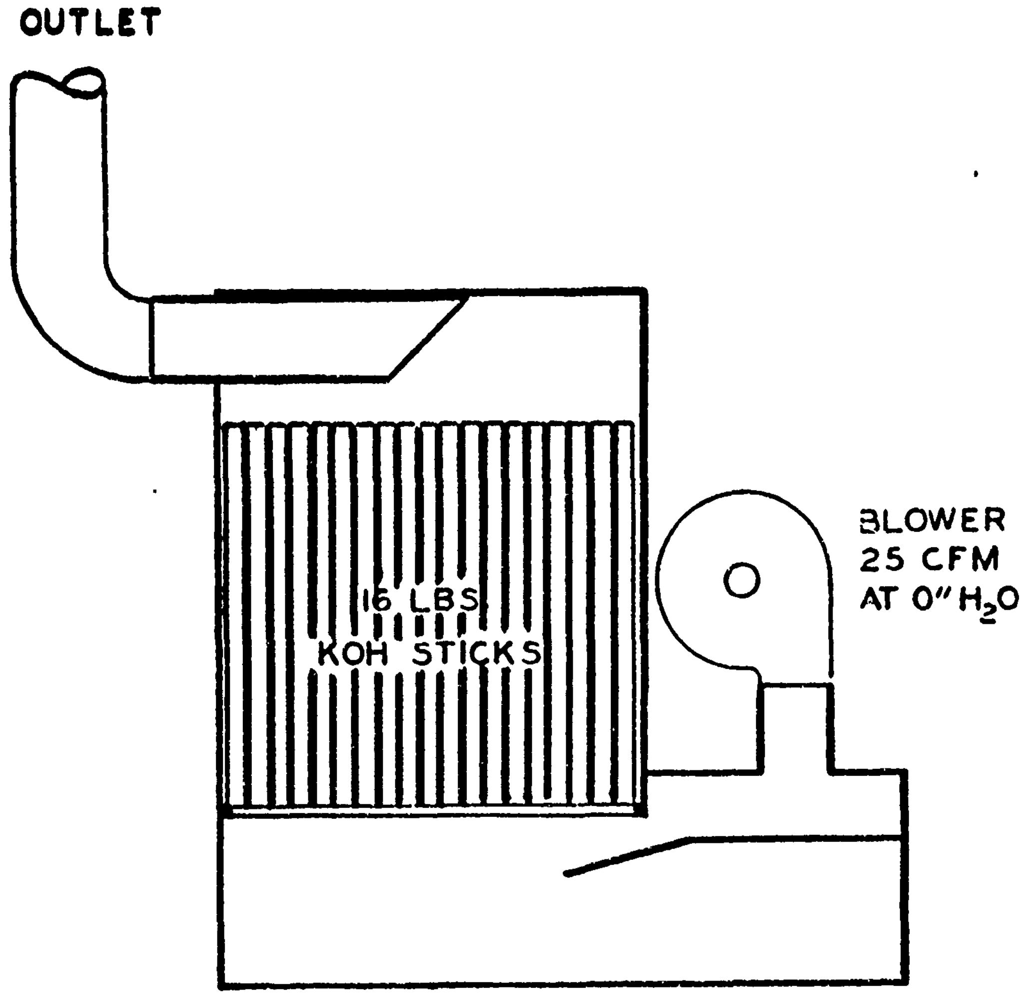


Figure 12. MANHIGH III Air Regenerator (Schematic)

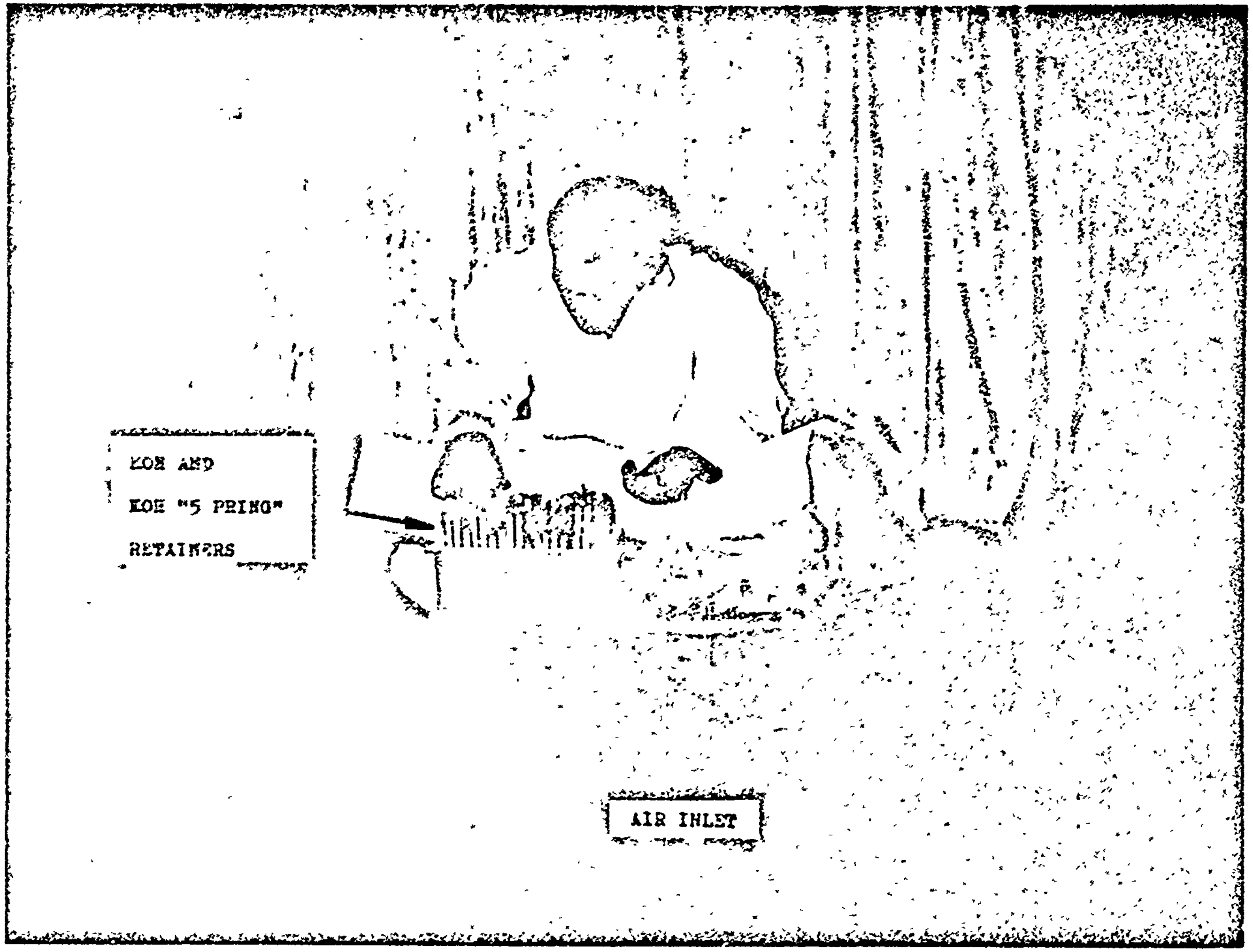


Figure 13. Air Regenerator Being Loaded

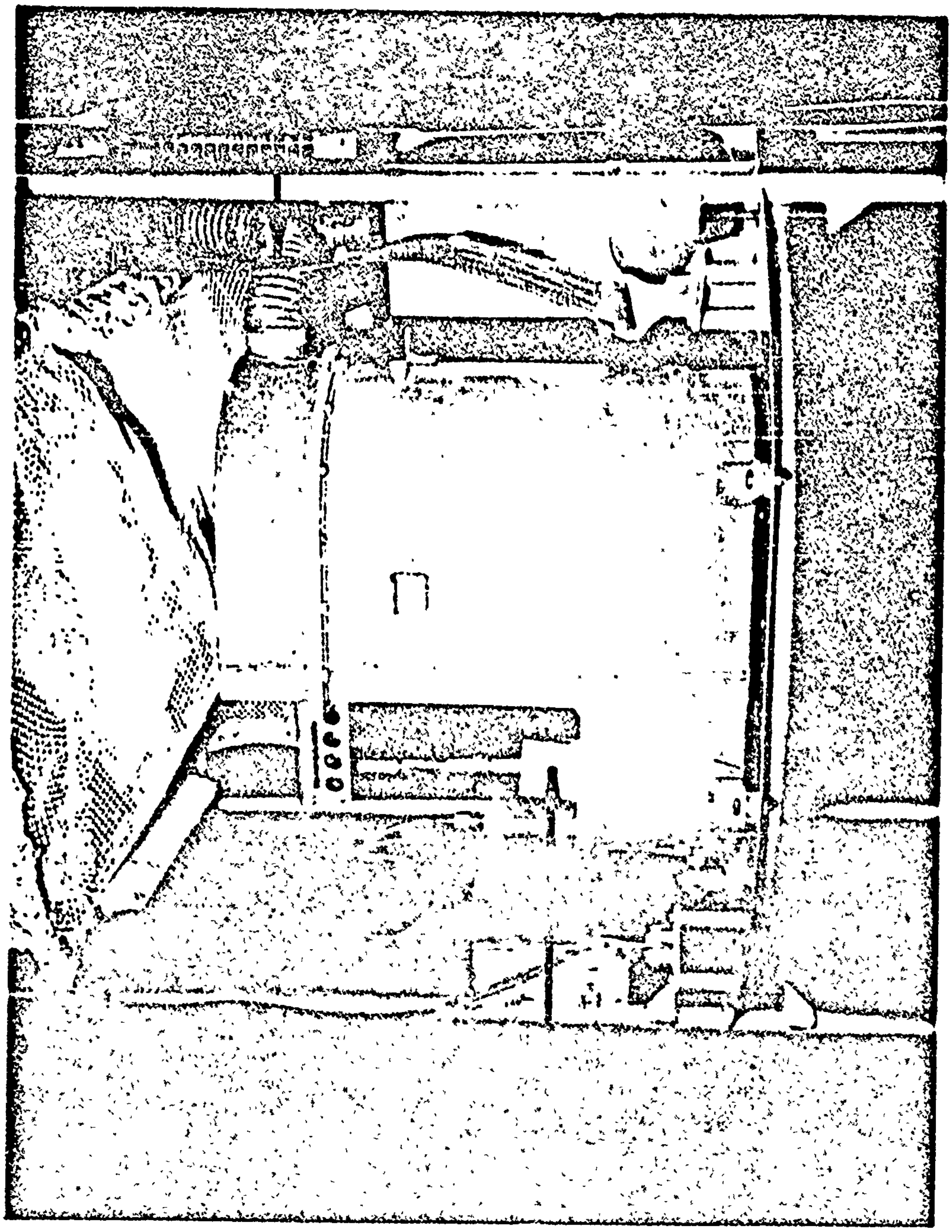


Figure 14. Rear View of Installed Air Regenerator

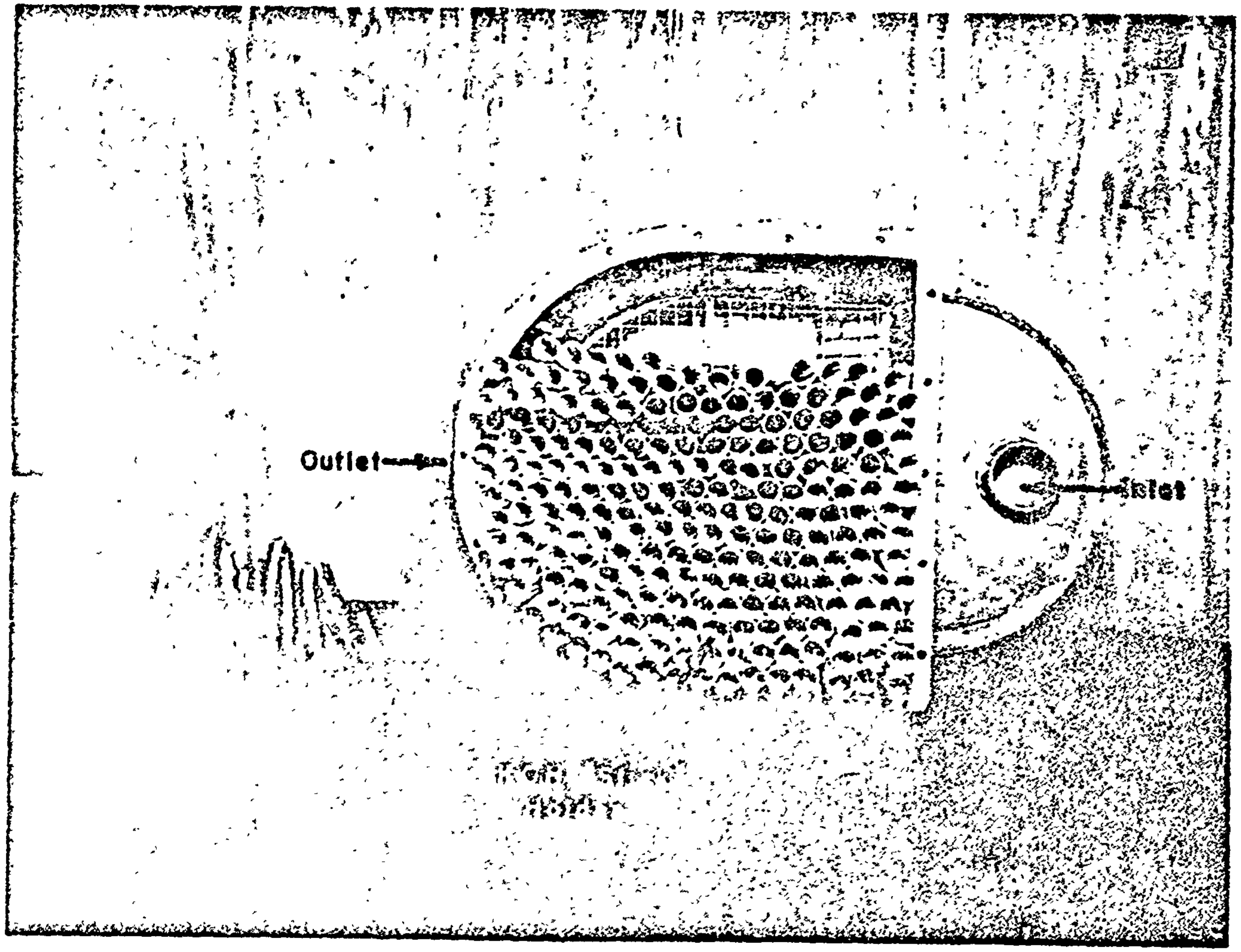


Figure 15. Top View of Air Regenerator

substitution was made because KOH offered greater activity in absorbing CO_2 and also because of its ability to absorb water. This single chemical could replace the three chemicals used on the previous flights. The unit was filled with approximately 16 pounds KOH in stick form inserted into one-half inch diameter steel spring retainers.

The operation of the unit was simple. Capsule atmosphere was directly drawn in by a 25 cfm blower, blown down into the lower liquid-collecting part of the regenerator, then passed up through the KOH sticks and through the outlet. The outlet was connected to a three-inch flexible hose which led up to a Y-valve. The pilot could use the Y-valve to direct the regenerated atmosphere into the dome ring, which distributed the air down over each porthole, or he could direct the air through another flexible hose normally discharging upward at head level. This hose could be used to direct the air on to the pilot for cooling, or toward other places if desired. In operation, the water in the capsule atmosphere was absorbed by the chemicals on the surface of the sticks; this surface became saturated with a solution of KOH-H_2O, and this solution dripped into the liquid-collecting part of the unit below. The incoming atmosphere was first blown over this liquid to try to gain the chemical use of this KOH solution.

This solution of KOH was very caustic; therefore, valves were installed in the outlet and inlet that could be operated by the pilot to seal off the unit during landing. The unit was also designed so that no liquid would reach the ports if the regenerator were lying on any side, a condition occurring if the capsule landed and then fell over.

3. Subfloor Section

The equipment below pilot-level was that equipment below the subfloor (Fig. 7), and included the electronic or "pie" section, the LOX converter, LOX buildup and evaporator coils, and the emergency battery packs for both 12- and 24-volt systems. The LOX converter was a Bendix type, five-liter, standard unit. The oxygen system was not entirely located under the subfloor as is shown in Figure 16. Every item in this system is fairly standard for LOX systems as used in aircraft and very similar to that used in the previous flights. With the exception of the automatic suit valve and the Firewel valve, all items in Figure 16 are standard and warrant no further description.

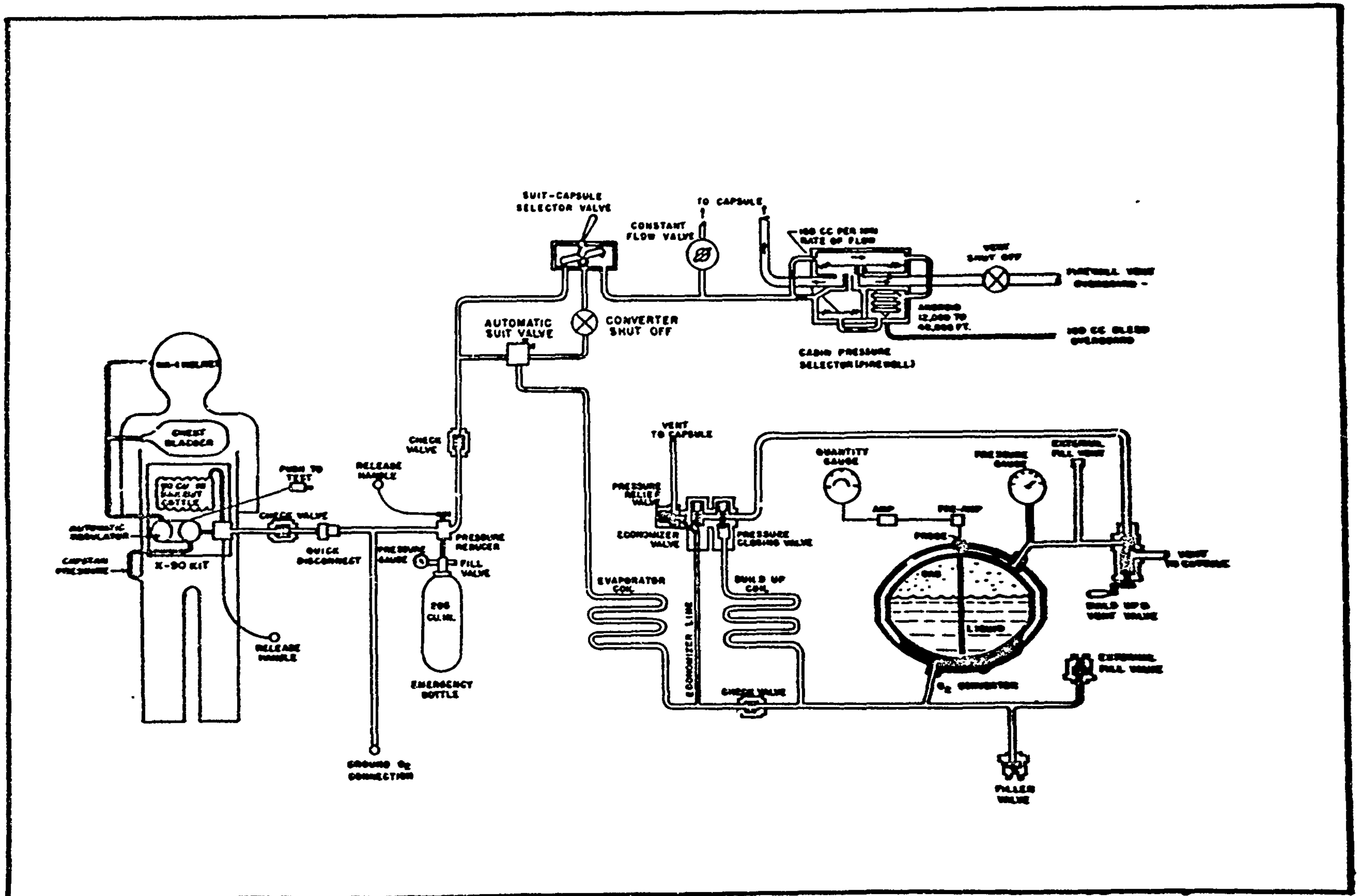


Figure 16. MANHIGH III Oxygen System (Diagram)

The automatic suit valve was an aneroid type switchover valve. It sensed total pressure, and if total pressure dropped to an equivalent pressure-altitude of 28,000 feet, would automatically switch the LOX-supplied oxygen over to the suit position. This valve could be reset from within. The Firewel valve controlled total cabin pressure by sensing any buildup of that total pressure over that set by the pilot on the aneroid mechanism, and venting the excess pressure overboard. The 160 cc bleed shown in connection with this valve was a controlled leak necessary for Firewel valve calibration.

The emergency battery packs were sets of LR-40 and LR-100 silver cells arranged to give an output of 12 and 24 volts. These batteries could not be used as ballast, as could the exterior batteries. Battery life was sufficient to allow normal descent with all equipment operating plus a margin of safety.

The electronic gear aboard the capsule was located just below the subfloor in a space eight inches deep with a diameter equal to the diameter of the internal assembly. Five separate sections were made from this assembly, the divisions resembling the divisions of a pie (Fig. 17). Each section could be removed individually, greatly simplifying maintenance, adjustment and necessary changes. Each section will be considered independently.

Section 1 - High Frequency Transmitter (Fig. 18). This high frequency transmitter was a unit built in Winzen Research Inc's. electronic shop to operate on 1740 kc. The unit was in constant use in flight, being modulated by a code keyer that gave outside altitude information. This transmitter was a second source of capsule-to-ground communications and could be voice-modulated for normal communications, or a Morse code keyer could be inserted in place of the altitude keyer for pilot code operation. The antenna of this unit projected from the lower half of the capsule, while the VHF antenna was installed on the upper dome. If emergency conditions dictated capsule separation, one antenna would remain to provide communications if either top or bottom marmon clamps were released.

Section 2 - High Frequency Receiver and Power Supply. A unit similar to this receiver is a standard part of the termination circuit. It was used in this case as a communications receiver. It was not dependent on the capsule power system but contained its own batteries capable of operating for more than 40 hours.

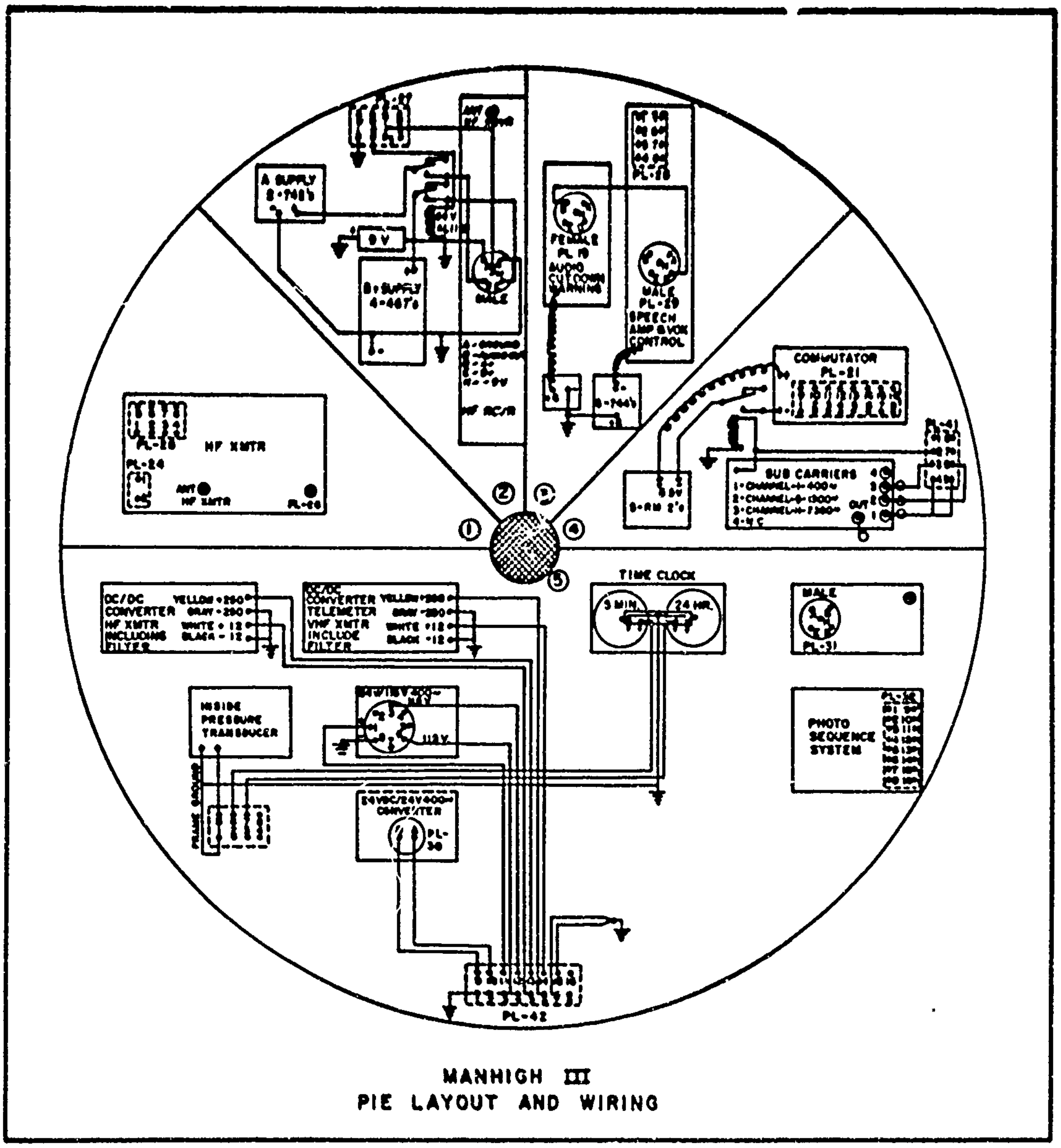


Figure 17. "Pie" Layout and Wiring

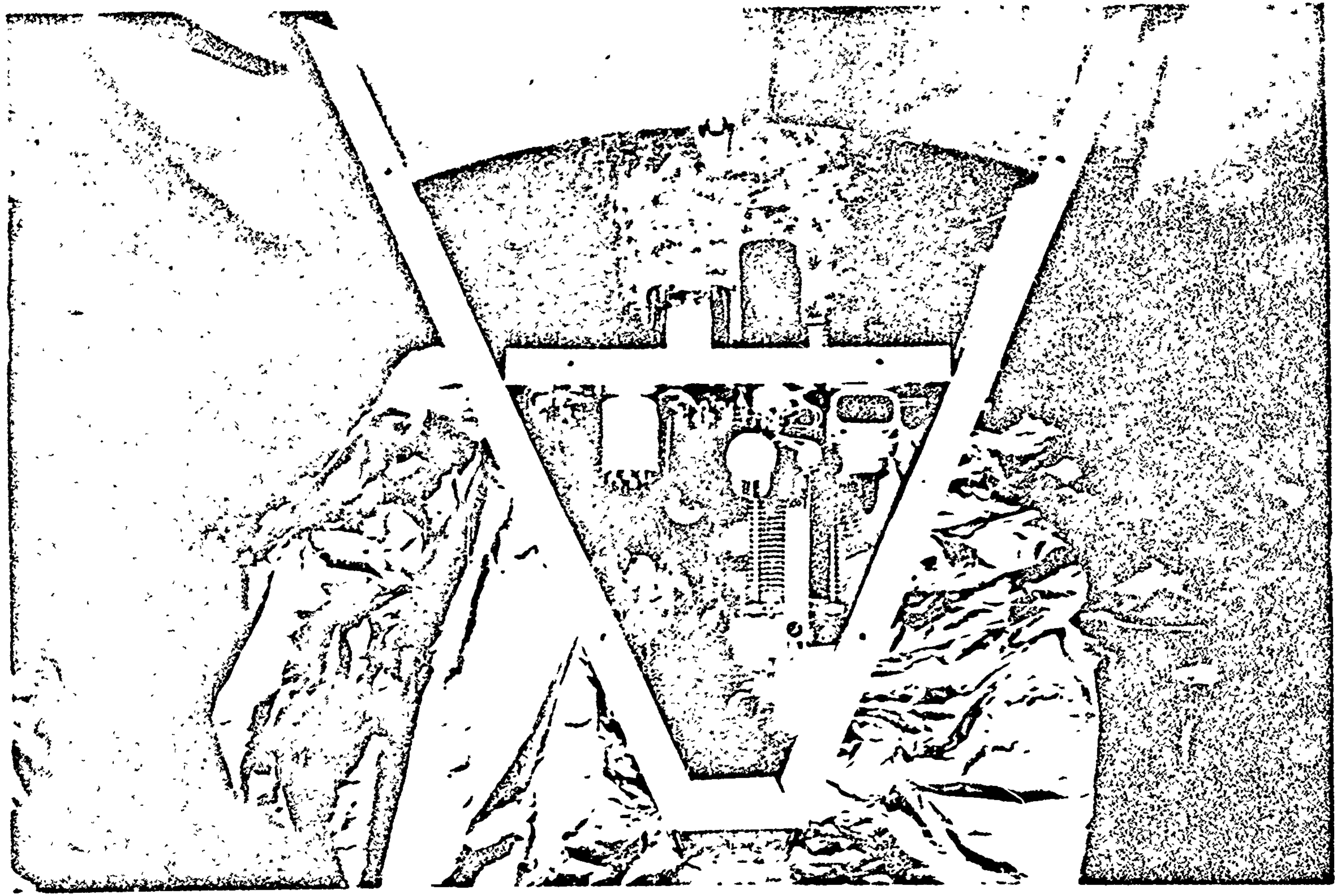


Figure 18. Top View "Pie" Section 1

Section 3 - Audio Cut-Down Warning Speech Amplifier and VOX Control. The audio cut-down warning would provide a tone in the pilot's headset when the 298.6 mc "gate" opening signal was received for five straight seconds by the termination receiver. This audio warning would occur simultaneously with the visual red light warning on the instrument panel. These devices forewarned the pilot that ground termination and cut-down had been initiated and would occur 30 seconds later unless the termination override switch was actuated. The VOX control allowed the pilot to bypass use of the foot switch and use this voice-operated relay for communications.

Section 4 - Commutator and Subcarrier Oscillator Sections. The subcarrier oscillator section was a standard, enclosed subcarrier assembly manufactured by Dorset Laboratories. The unit had provision for four standard FM-FM telemetry channels. Three of these channels were used - Band 1 of 400 cycles per second subcarrier frequency, Band 5 of 1300 cps subcarrier frequency, and Band 11 of 7350 cps subcarrier frequency. Band 1 was modulated by the respiration sensor output, Band 5 was modulated by the output from seven sensors through a commutator which allowed the telemetry of these seven items on this single channel, and Band 11 was modulated by the output of the EKG sensing apparatus. All sensing circuits had voltage outputs designed for and adjusted to the subcarrier assembly input acceptance range of from 0 to 3 volts. The three FM subcarrier oscillator sections were all voltage-controlled oscillators with a ±7-1/2 percent modulation. The three channels of information were fed into a mixer and the composite signal output of this mixer was the modulating signal for the final stage FM telemetry transmitter, operating on 227 mc.

The commutator was a ten-point, pulse-switched type commutator. It allowed the outputs of seven sensors to be switched alternately every 30 seconds to modulate the subcarrier Band 5 of the telemetry system. The high-voltage calibrate signal feeding the commutator consisted of a standard voltage of three volts. A shorted lead was used for low voltage calibration (zero output calibration), a clock-driven, five-minute stepping resistance for five-minute time information, a one-hour, clock-driven stepping resistance for hourly information, a bellows-type inside pressure transducer for inside pressure (altitude) information, a thermister-type sensor located in a ventilated cage just under the pilot's seat, for capsule inside temperature information, and the BSR sensor circuit. The commutator gave information in the following sequence:

Calibrate High

Calibrate Low

Time Hour

Time Minute

BSR

Inside Pressure

BSR

Inside Temperature

BSR

Inside Pressure

Section 5 - Photo Sequence System, Power Supplies, Telemetry Time Clocks, and Telemetry Inside Pressure Transducer. Power supplies consisted of two DC/DC converters for supplying 250 volts to the HF transmitter and a 24V DC/24V 400 cps AC converter to supply power to the autosyn compass. The input to the HF supply units was 12V DC, and the input to the autosyn compass converter was 24V DC. The time clock transducers were clock-driven type commutators providing a stepped resistance that changed value every five minutes and also every hour. The inside pressure transducer was a bellows-operated, low-altitude transducer. The photo sequence system was a motor-driven, commutator type that had two speeds, the pilot being able to select either one. The fastest speed and fastest frame rate was to be used on ascent; slower speed was for film conservation when floating at altitude (see Chapter XII).

4. Medical Electronic Circuits and Sensors

The medical electronic apparatus consisted of the suit harness and modified X-90 kit, EKG, BSR, respiration and body temperature circuits.

The "suit harness" was composed of EKG, BSR, and three body temperature sensors and their leads. The leads were threaded over the suit underwear where possible, but always under the suit itself, until they reached a point where exit through the suit could be made. Outside the suit they were threaded loosely up the capstans in a manner that would not interfere with pressure suit operation. The leads were put through a special junction made into the X-90 kit and from there went to capsule electronic sections via cable with quick-disconnect (Fig. 19). The two skin-temperature sensors were held in place by pressure-sensitive

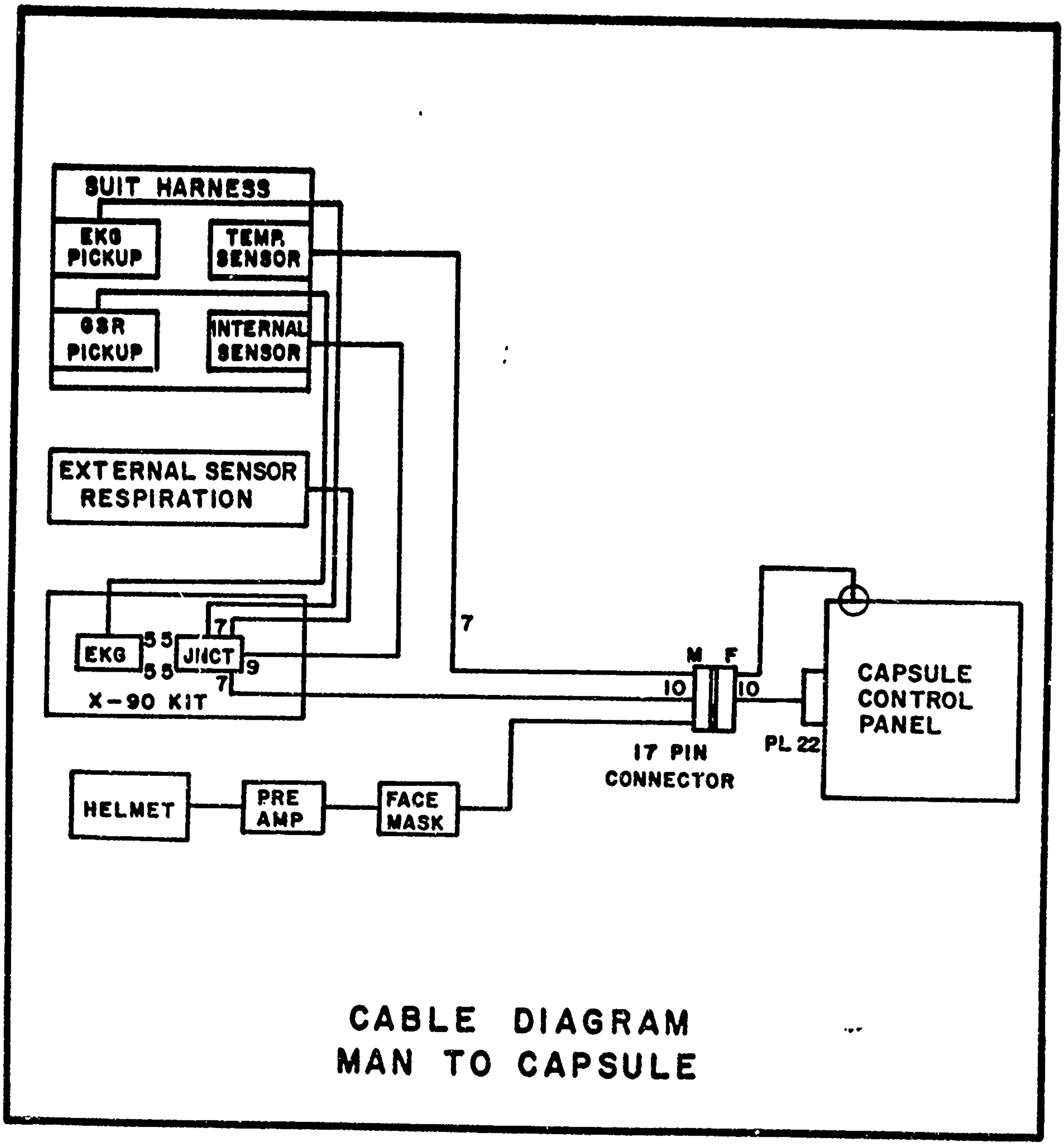


Figure 19. Cable Diagram Man to Capsule

tape, as were the EKG electrodes on chest and back. These were kept from slipping by an additional elastic bandage wrapped around the chest. Pressure-sensitive tape was also used for the BSR leads.

a. The EKG Circuit.

This circuit was provided in order to obtain heart rate and EKG wave form continuously in flight. This function was provided by using the output of a bridge circuit to modulate the subcarrier Band 11. Three leads were attached to the subject, one at heart apex, one on the right side of the subject's back at the trapezius, and one, the ground lead, on the subject's left ankle (this also was common ground connection with BSR circuit). There was a standard voltage of 6.75 volts applied across the bridge. The subject's heart output unbalanced this bridge an amount proportional to this output; this imbalance was put into the EKG sensor amplifier (Fig. 20), and the amplified signal was fed into Band 11 subcarrier section. This band had the highest response (from 0 to 110 cps) of the three bands available. The heart rate information was expected to be the highest cycling information telemetered; therefore, it was put on this band with highest response.

b. BSR Circuit.

This circuit was also a bridge circuit, the output of the circuit being put directly into the subcarrier oscillator (Fig. 21). Between the subject's right arch and the common electrode on the left ankle was the BSR variable resistance portion of the bridge. This circuit was in parallel with a fixed resistance of 100k ohms. This parallel combination formed one leg of the bridge circuit, the other three legs being precision 40k-ohm resistors. Mercury cells provided a standard 12 volts across the bridge. Fluctuations in the skin resistance caused unbalancing of the bridge, providing an output voltage fluctuation proportional to the skin resistance. This bridge output modulated the subcarrier channel five; this channel had a response of from 0 to 20 cps.

c. The Respiration Circuit.

The respiration sensor was a small carbon microphone held against the lower left side of the chest, on the outside of the suit, by a belt around the subject. The variations in the resistance of the carbon microphone resulting from expansion and contraction of the chest caused signal variation in the bridge of which it was a part (Fig. 22). This

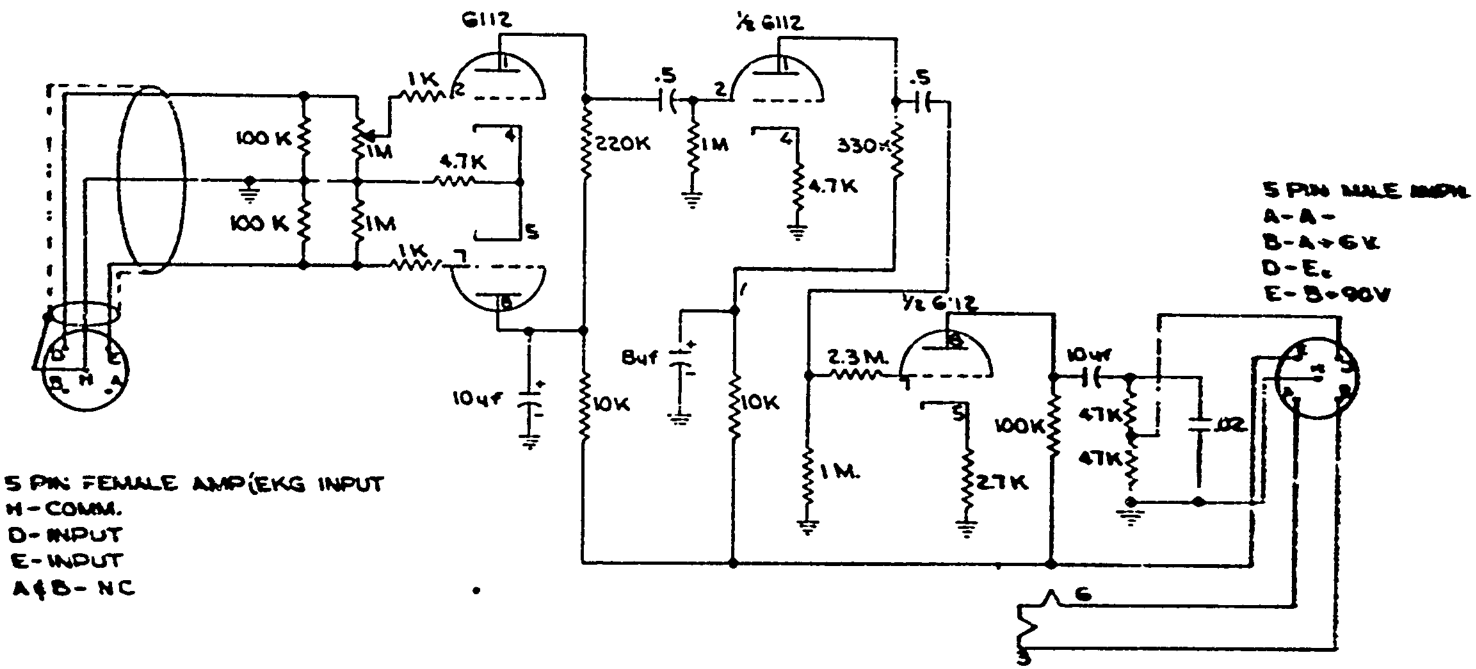


Figure 20. EKG Sensor Amplifier

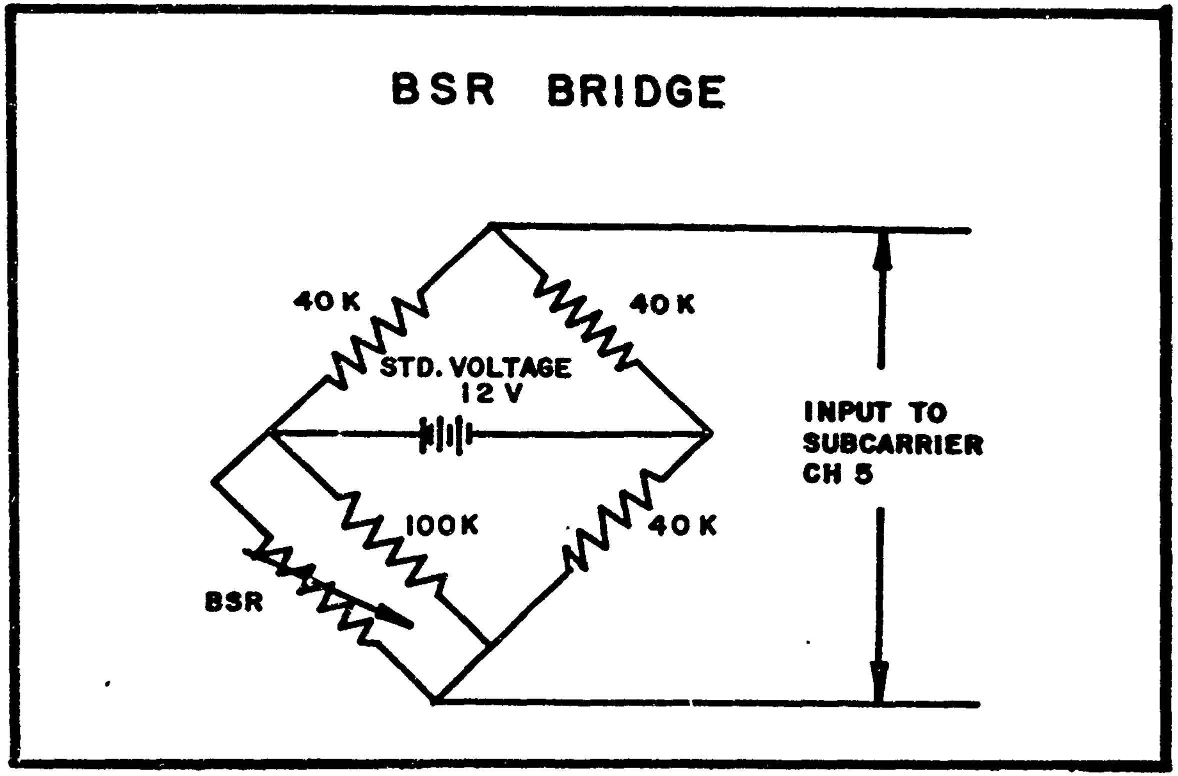


Figure 21. BSR Bridge Circuit

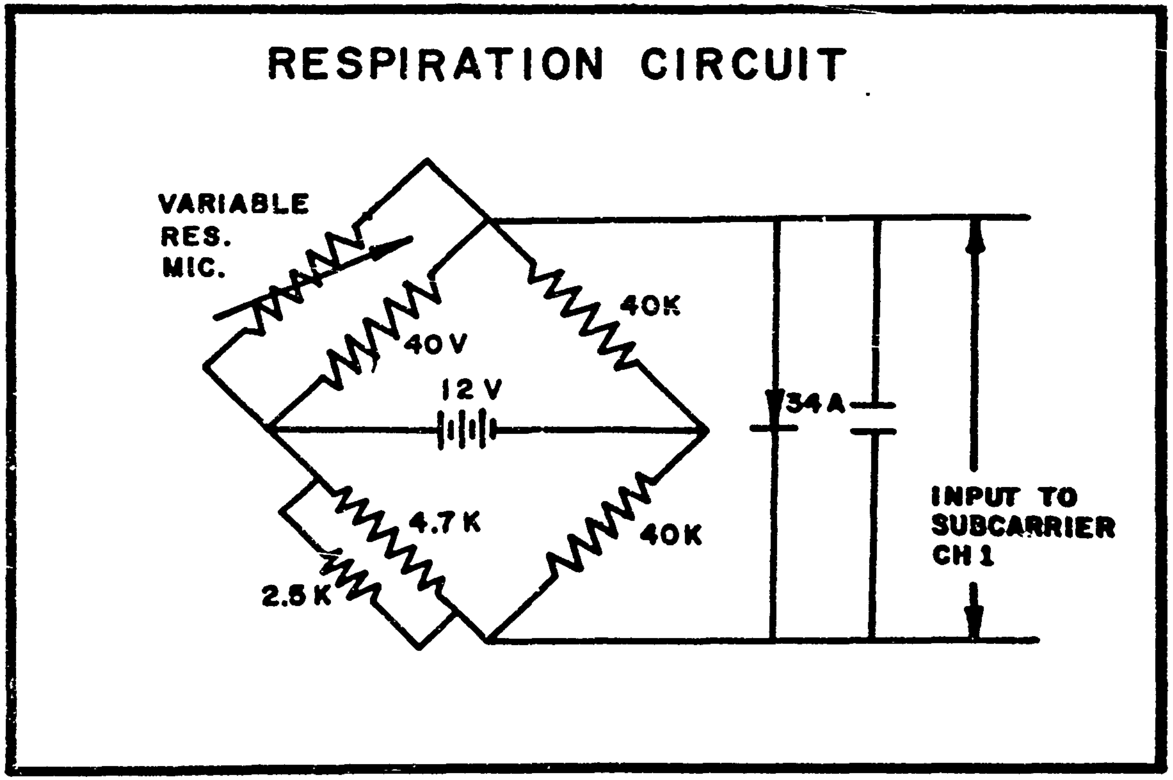


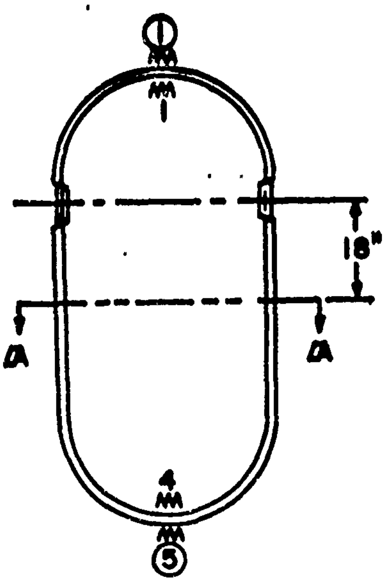
Figure 22. Respiration Circuit

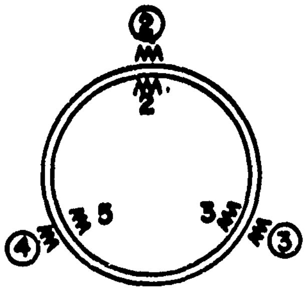
signal was the input to subcarrier Band 1. This band, with a no-signal frequency of 400 cps, had the lowest response (6 cps). As the respiration was expected to have the lowest fluctuation rate of the information transmitted, it was put on this band.

d. Temperature Measuring Circuits.

The body temperatures taken from the subject during flight were not telemetered, but were measured in the cockpit and voice transmitted by the pilot. The measuring circuit was of the null balance potentiometer type. Internal temperature measured on the subject was rectal; external, right thigh skin and right ankle skin. Since the circuit was a potentiometer, all sensors were variable resistance type. The rectal sensor was a thermister probe and the other sensors were flat, thermal-ribbon type probes of 675.5 (±0.5) ohms at 77°F. There were five additional capsule temperature points measured with this same circuit for a total of eight measurements. In use, the pilot would select the temperature to be measured with an eight-point switch; the potentiometer adjusting knob would then be moved to bring the galvanometer deflection to zero, and the temperature read directly from a scale attached to the galvanometer adjust knob. The scale was graduated in degrees Fahrenheit and presented a reading to the the tenth of one degree. The locations of the eight temperature points are given in Figure 23.

Note: Figure 24 shows the X-90 Kit Wiring and Figure 25 is a Block Diagram of MANHIGH Capsule Electronics.





SECTION A-A

NOTE:
CIRCLED NUMBERS ARE WADC CHAMBER TEST THERMOCOUPLE POSITIONS.

INSIDE THERMISTOR LOCATIONS

1. CAPSULE TOP
2. CAPSULE FRONT
3. 120° RIGHT OF FRONT
4. CAPSULE BOTTOM
5. 120° LEFT OF FRONT
6. SUBJECT RECTAL THERMISTOR
7. SUBJECT FOOT THERMISTOR
8. SUBJECT THIGH THERMISTOR

THERMISTOR LOCATIONS INSIDE CAPSULE

Figure 23. Thermistor Locations Inside Capsule

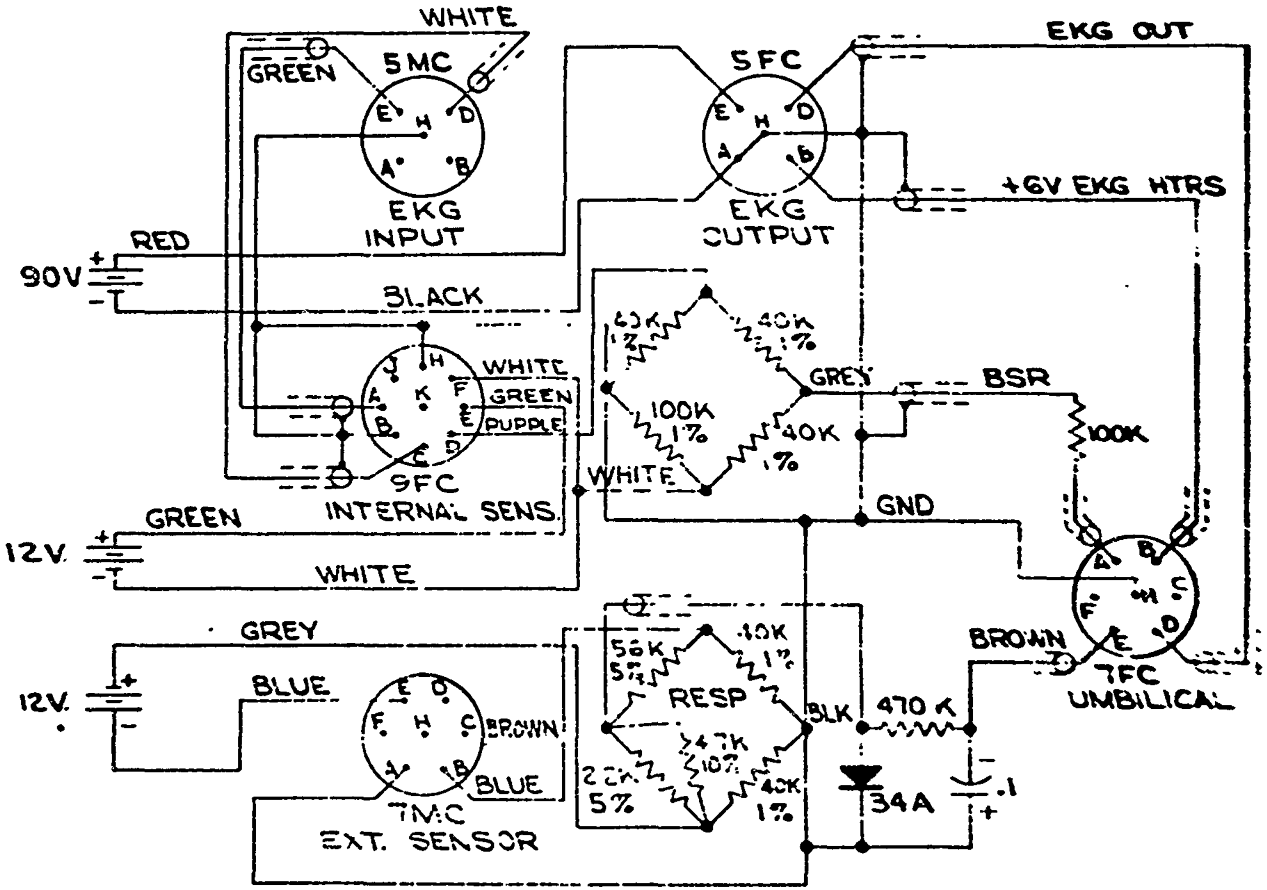


Figure 24. X-90 Kit Wiring

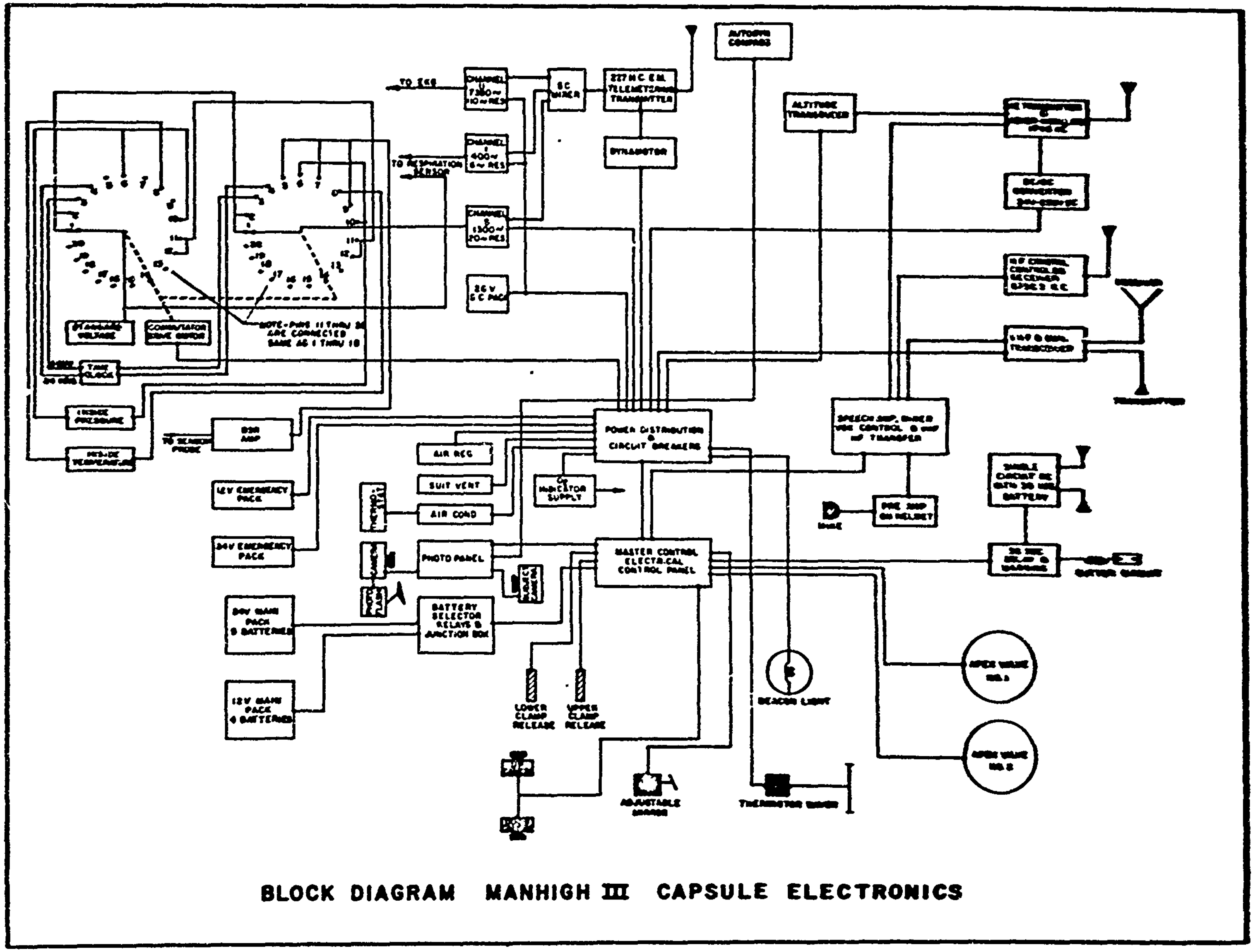


Figure 25. Block Diagram MANHIGH III Capsule Electronics

B. BALLOON PERFORMANCE AND METEOROLOGY*

1. Meteorological Parameters

The meteorological parameters to be considered on a 30-hour manned stratospheric balloon flight are as follows:

a. Surface temperature.

Surface temperatures of roughly -20°F or colder should be avoided if possible. Although the balloon passes through colder layers during ascent, maximum stress is often encountered during the launching process. Moderately high temperatures can also be disconcerting because of the tendency of the helium to superheat. This obscures the weigh-off process by indicating excess lift which would dissipate after launch when ventilation commences.

b. Temperature Inversions Close to the Surface.

Steep inversions require extra initial free lift or ballast for penetration. Conceivably, they may be employed for braking action during a landing.

c. Surface Winds.

Three knots was the estimated maximum acceptable value for a pit launch with this particular three million cubic footer. Inflation without pit protection requires approximately 1.5 knots or less. The MANHIGH III flight configuration required these light winds to almost 400 feet above the ground. In sporadic cases, surface wind shear at launch is also important. A strong temperature inversion may protect the first 400 feet from a 15-knot wind, prior to launch. Encountering this shear immediately after launch may prove fatal to the balloon because of its condition of maximum flaccidity. A radical change in direction of a constant wind field as low as 8 knots would be more disastrous.

d. Trajectory During Ascent.

It is important that the balloon is not upwind of a large water surface or mountains when encountering a jet stream or the tropopause.

e. The Jet Stream

Shear rather than wind speed is the most significant factor. However, measurement and detailed knowledge of shear are

* By Mr. B. D. Gildenberg

still somewhat limited. Consequently, maximum wind speed is used as an indicator of potential shear. Eighty knots would be the approximate limit for this manned balloon.

f. Tropopause Condition.

Precisely, it is the minimum temperature encountered during ascent which is important here, rather than the temperature of the true tropopause. For a stratosphere balloon flown in the United States, this will be someplace between 35,000 and 55,000 feet, MSL. In Minnesota the minimum temperature is almost always warmer than the brittle temperature of polyethylene (-68° to -70°C). However, the presence of the jet stream level at the tropopause level, magnified the effects of both components.

In New Mexico, the minimum temperature is occasionally colder than polyethylene brittle temperature, and frequently close to it (average is about -68°C). This problem is somewhat alleviated by the height of the almost tropical tropopause (55,000 feet MSL), and the subsequent light wind speeds found there. Furthermore, the seasons of minimum temperatures and maximum wind speeds are happily out of phase. Statistical breakdown of about 500 flights at Holloman Air Force Base, indicate that -72°C is an excellent borderline for balloon tropopause mortality.

g. Floating Altitude Trajectory.

This must be forecast carefully in order to formulate the logistical plan for the flight. Ground and air tracking units must be pre-positioned, and some conception of the landing terrain established. A trajectory over mountain terrain, for instance, equates to greater ballast requirements.

h. Parachute Drift.

Prior to the flight, and during the flight, when fresh data are received, the parachute drift from altitude should always be available to the flight control officer for consideration during emergency conditions. This factor became a reality during MANHIGH III.

2. <u>MANHIGH III Meteorological Case History</u>

a. Initial Schedule.

The flight was initially scheduled for Minnesota in August. MANHIGH II had been flown the same month from Minnesota, and experience vividly indicated that it was a relatively unfavorable time for this type of balloon flight. In order to assure the

specified launch conditions of three knots or less, one had to be within 100 miles of the center of a high pressure area. The "go" sign for a manned mission must only be given during launch conditions of high reliability due to the complicated and wearing processing of the subject which is required. During August, the balloon will drift a short distance (10 to 50 miles) eastward, and at about 70,000 feet, reverse direction, proceeding westward for the remainder of the flight.

The anticyclone (high pressure area) during this period, is usually moving eastward, and within perhaps ten hours, the balloon is located over the western perimeter of the anticyclone. Minnesota and South Dakota are especially notorious for a high incidence of cloudiness.

If the launch site is just south of an east-west stationary front, a satisfactory lull can occur. Coming in from Canada to northern Minnesota, these fronts contain low, but fragmentary and generally scattered, cloud conditions. However, they are notoriously fickle, and may accelerate at any time.

Cols are more infrequent, but also treacherous with respect to duration of lulls.

A climatological investigation prior to MANHIGH III indicated that the most reliable situation would be a strong hurricane block off the east coast. Naturally, this is a relatively rare occurrence. Eight years of data averaged out to 1.5 "go" days from 15 to 30 August. The minimum case was zero, the maximum five.

b. Delay of Launch.

Delay of the launch until late September resulted in a new set of meteorological parameters, and a temporary improvement in the number of "go" days. With the advent of winter, surface anticyclones are larger in area and depth, providing more extensive calms and minimum cloudiness.

The floating altitude trajectory is also altered by the following process. During the summer, the stratosphere is under the influence of a huge anticyclone centered in the Artic regions. This massive, static system extends to Mexico, and easterly flow (winds blowing east to west) prevails throughout the United States. By September, at 100,000 feet MSL, this anticyclone is rapidly breaking down, and being replaced by a winter cyclone which will eventually occupy almost the same domains.

This phenomena occurs first at higher altitudes and higher latitudes, earlier in the season. In 1958, for instance, it occurred by 15 August at 95,000 feet MSL at 55 degrees latitude, and 25 August at 115,000 feet MSL over the states. The shift at higher altitudes, therefore, can serve as index to the shift at 100,000 feet MSL.

The map analysis at 100,000 feet is concerned only with streamlines. Temperature data above 25 millibars (83,000 feet MSL) are practically non-existent. The number of stations providing wind data at 100,000 feet MSL and higher are sampled in Figure 26. July and August are probably the months of highest frequency (Fig. 27).

The rectangle symbolizes the borders of the United States; the circle, the town Crosby, Minnesota. By 26 August at 115,000 feet the anticyclone was centered over the United States, rather than Canada, and westerly flow would now be encountered over Crosby. Simultaneously, at 100,000 feet, the flow was still easterly. The radiosonde run from Seattle, graphically illustrates the shift from one regime to the other - summer at 100,000 feet, and a whiff of autumn at 110,000 feet. The mean flow for September at 120,000 feet at the bottom of Figure 27 illustrates an even more advanced state of winter in the high stratosphere. The Canadian trough has penetrated as far southward as Kansas, and the Pacific and Bermuda high pressure areas advance from the coasts. In the final picture for winter, the Canadian cyclone, centered in the Arctic in place of the summer anticyclone, will dominate the United States, except for sporadic invasions of the Pacific High, and sporadic protrusions of the Bermuda High over the Gulf States.

By 21 September, daily surveillance of the stratospheric winds was initiated. At this date, the structure at 100,000 feet closely paralleled the 115,000 feet situation shown in Figure 27. This was a fortunate circumstance, for the balloon would then move eastward with the surface anticyclone and literally track the good weather. Furthermore, the northerly component would help avoid the Great Lakes, and speeds were only about 10 knots.

On 24 September, the first sign of the Canadian trough appeared. The trajectory shifted due eastward, and increased in speed. This bearing inferred the Great Lakes; a stiff south-easterly climb-out would be required to avoid them. Apparently we were slipping past the ideal time for this flight in the Minnesota area. This would have been between 20 August

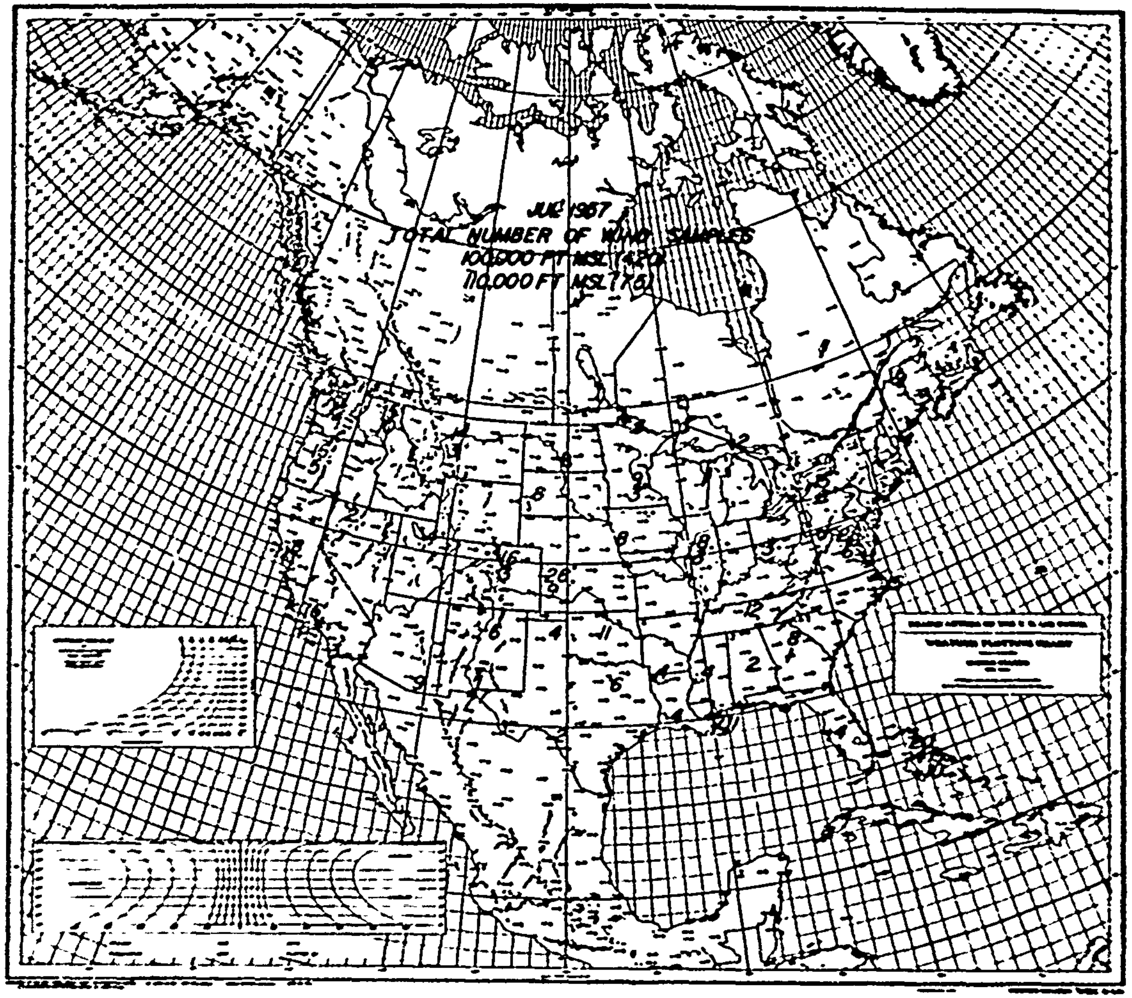


Figure 26. Frequency Chart of Wind Data at 100,000 Feet and Higher

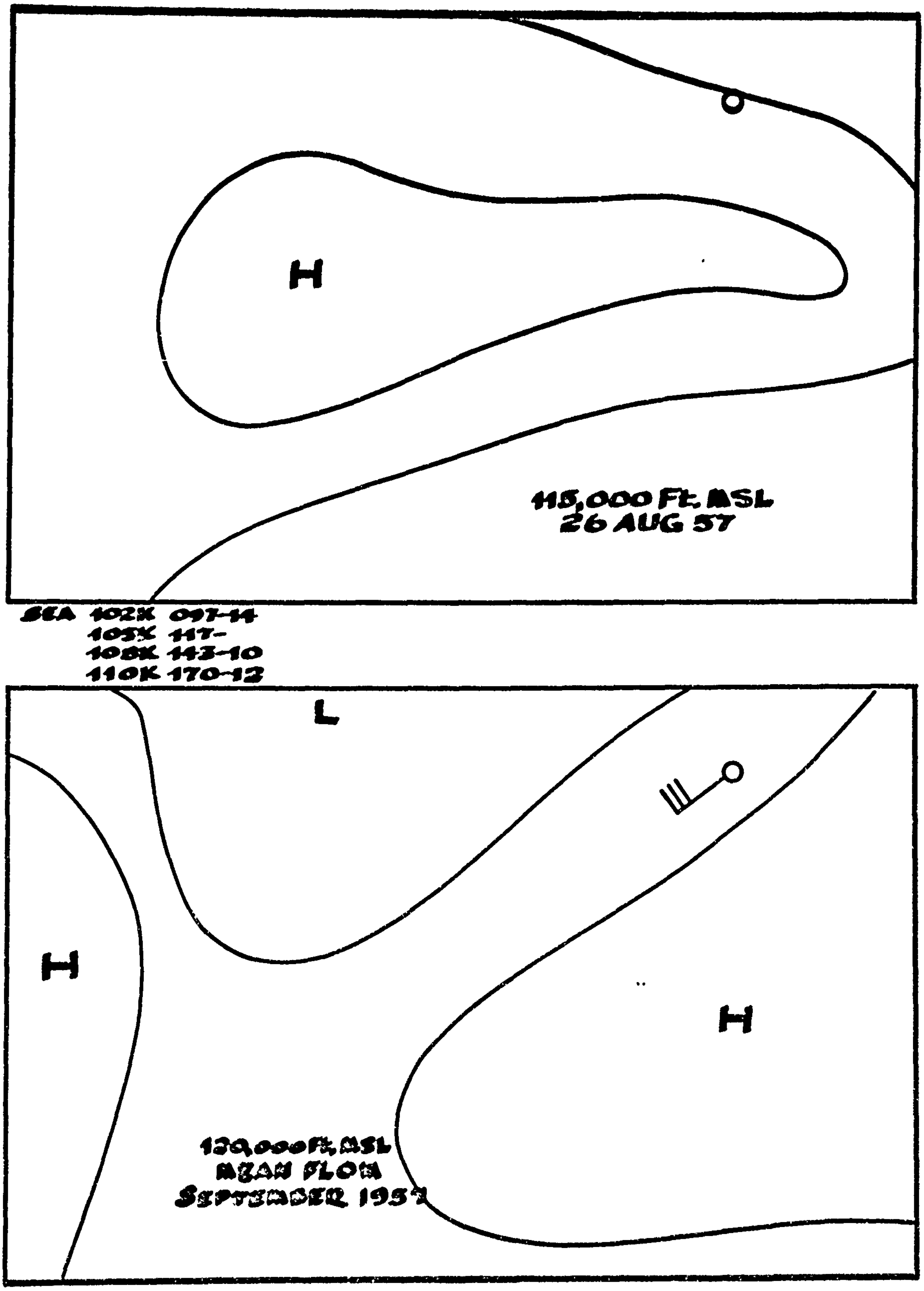


Figure 27. Streamline Analysis August and September 1957

and 20 September, when the shift from westerly flow to easterly flow occurred, resulting in speeds less than 15 knots.

The maps for 26 to 29 September on Figure 28 looked identical to the 120,000 foot MSL mean map for September. A floating trajectory from 240 degrees at 20 knots equated to a landing on rugged Canadian terrain.

The rapid entry of the Canadian trough prompted a check of the 1957 data for early October at 100,000 feet. These indicated a very nearly linear increase in speeds, with 50 knots established by 10 October. Even by 6 October, it was 30 knots, which would have carried the balloon over the Atlantic. The project officers, consequently, were alerted to a possible Minnesota cut-off by the second week in October. That same evening further negative evidence was noted; the weather stations INL and SSM indicated sporadic readings of 35 to 50 knots. Scrutinizing the 1957 data more carefully, it became apparent that these stations on the Canadian border, roughly once a day, picked up sharply increasing winds. The rest of the states reported fairly constant speeds. This then represented the southern perimeter of the 50-knot wind belt, which in 1957 penetrated Minnesota by 10 October.

By the next day, 30 September, it was winter in the Minnesota stratosphere. The bottom of Figure 28 illustrates this condition, with INL and SSM displaying a persistent 50 knots, and the weather station STC, a wind of 40 knots. This trajectory meant flight termination over Nova Scotia. Comparison with the same map for 1957 (Fig. 29), demonstrated that winter had arrived one week later that year at 18.9 miles.

The next chance in Minnesota would not have been until November, because between November and January, the strong winds are sporadically interrupted by outbreaks of light easterlies in the stratosphere, especially in seasons when the Pacific High is more pronounced. However, some years this may not occur at all; therefore, long periods of stand-by would have been required.

A conference was held in which attention was called to the very favorable meteorological regime currently reigning over Holloman Air Force Base, New Mexico.

c. The Flight.

The map of 6 October (Fig. 29) illustrates the average conditions existing prior to and during the MANHIGH III flight. Holloman Air Force Base was located in the col, between the Canadian trough and the western tip of the protruding Bermuda high

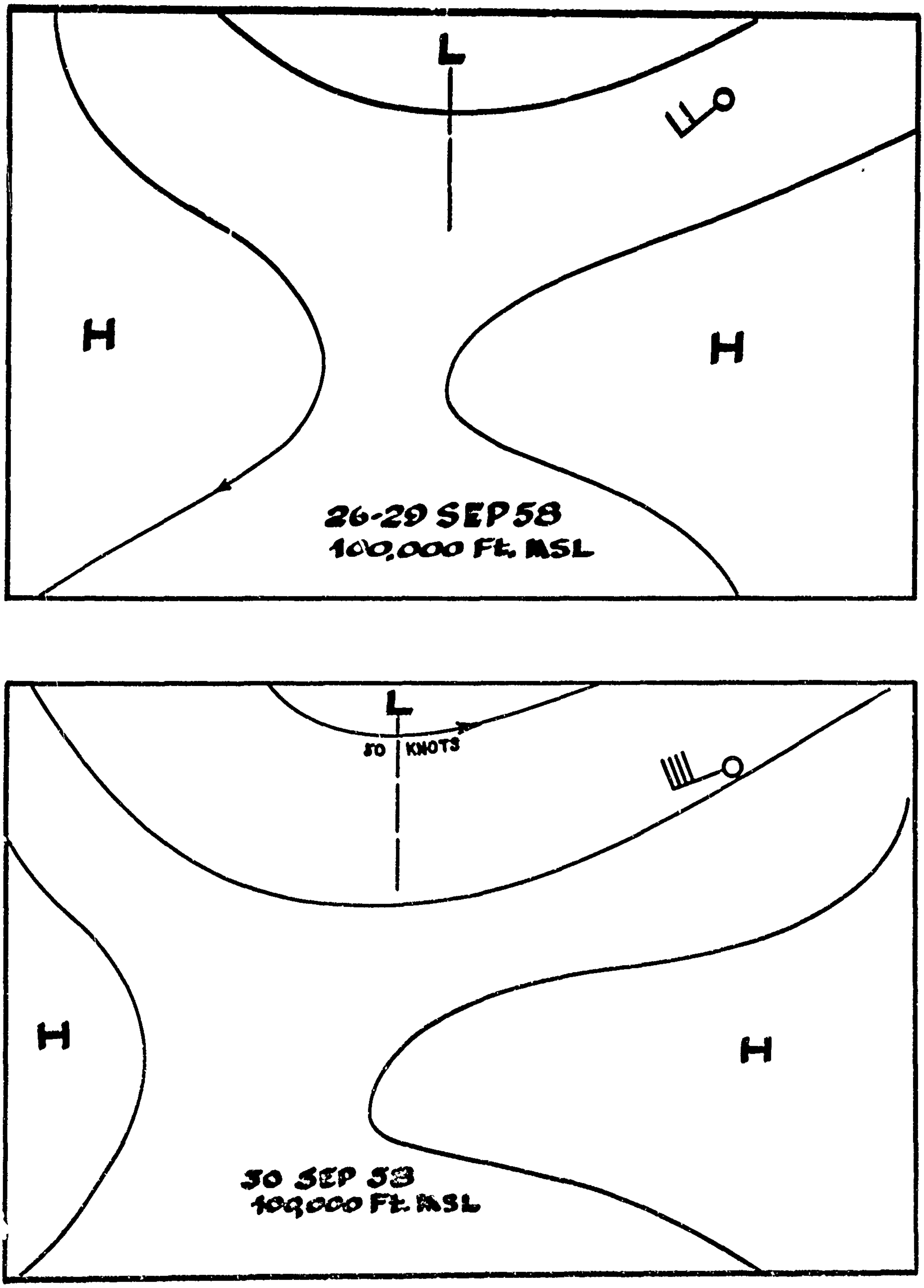
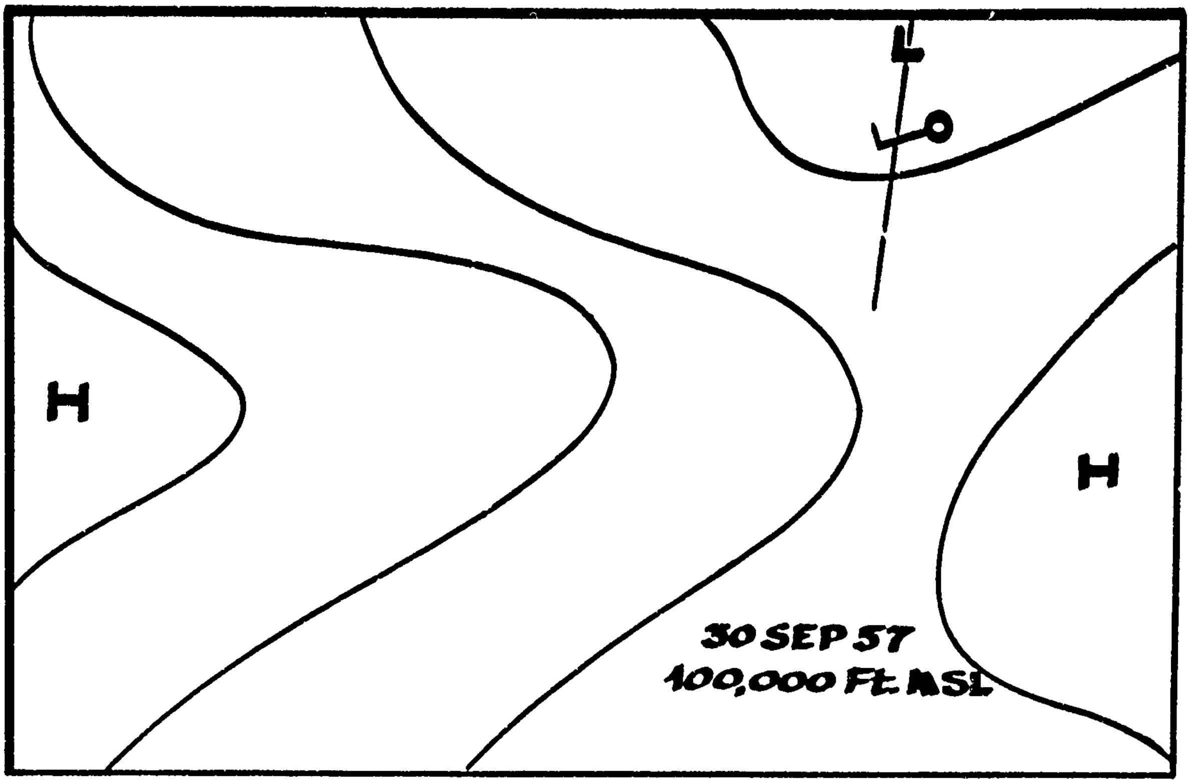


Figure 28. Streamline Analysis 26 to 30 September 1958



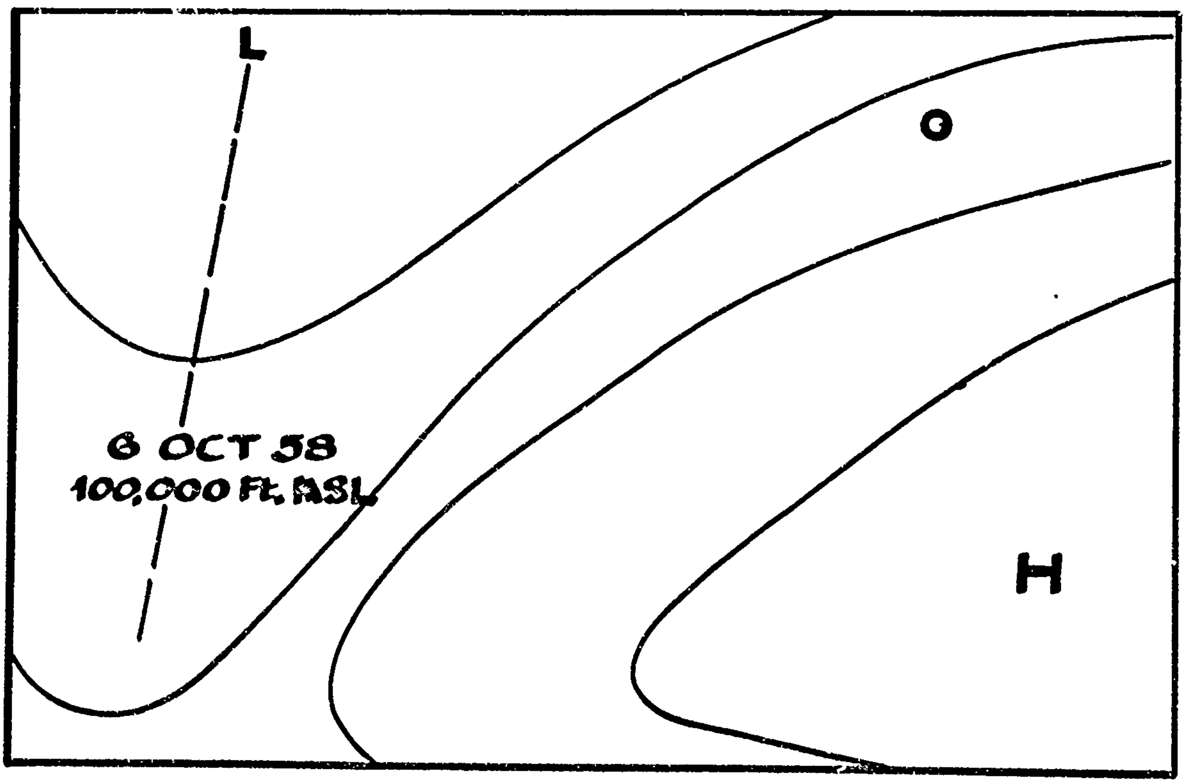


Figure 29. Streamline Analysis of 30 September 1957
and 6 October 1958

pressure area; therefore, the float winds were light and variable. Additional meteorological advantages were offered in the relative scarcity of frontal activity, and the sheltered Tularosa Basin, which permitted vertical inflation of skyscraping balloons, without a pit. A further advantage was the presence of the greatest concentration of tracking instrumentation in the country.

The perfections of this desert launch site were exemplified in the cloud conditions. For a five day period, including the actual flight, there was less than one-tenth cloud coverage. Visibility was never less than 60 miles. During the flight, only a few cumulus appeared in the afternoon over the Sacramento Mountains.

Prior to MANHIGH III, balloons of two million cubic feet had been vertical-inflated in this area, but nothing larger. There had been, however, some successful launches with a one thousand foot load line deployed. Ten years of plastic balloon launching experience in the Tularosa Basin indicated that the handling of larger balloons in the vertical position, was feasible.

Holloman Air Force Base is located in a basin with steep walls 5000 feet high on the eastern perimeter close to the base, and averaging 3500 feet on the western perimeter. The topographical daytime flow is up the basin from the south. At night, cold air drains off of the Sacramento Mountains from the east, almost always penetrating to the Base. During the switch from the nighttime to the daytime regime, there is inevitably a lull. The gradient wind in general is light because of the blocking of the prevailing westerlies by the bordering mountain ranges. This topographical profile is also excellent for persistent surface temperature inversions.

The time of the lull may vary from day to day in duration and time of occurrence, and must be forecast to assure a launch prior to the onset of increasing wind speeds heralding the daytime regime.

Initially adhering to the philosophy of launching on a perfect day, layout of the first MANHIGH III balloon was delayed until the lull actually commenced. Unfortunately, problems with the reefing sleeve delayed the completion of inflation until 1000 MST, exceeding the termination of the lull by one hour. At this time the wind increased to over 8 knots and destroyed the balloon by ground contact.

On the next attempt, it was agreed to layout on a time specified by the forecaster, prior to the advent of the lull if necessary. This was the technique employed on standard AFMDC launches and has proved to be highly reliable on many occasions under different conditions. This was confirmed once more by the MANHIGH III launch.

The gradient wind (above the surface friction layer) was northwest. Pilot balloons were launched every hour all night long by Air Weather Service. Approximately 30 minutes prior to the desired layout time, there was still no sign of the easterly drainage from the Sacramento Mountains. It was decided to drive a car toward the mountains to check the progress of the drainage and the relative strength. Just prior to this action, the forecaster suddenly felt a slight motion of cool air from the mountains barely three feet off the ground. All other levels were still northwest. The signal to initiate layout was given.

The situation was an obvious one, especially since the easterly drainage had a slight southerly component. The northwesterly gradient wind was only five to seven knots, and the vectors almost exactly balanced. The mountain drainage gradually acquired momentum, and was soon in evidence up to several hundred feet. By inflation time, it was only .5 knots and launch was performed at 1.5 knots. Three hours after launch, it was still almost calm.

The tropopause temperature two days previous to the flight was -72°C, i.e., marginal for a manned flight. However, the flow at minimum temperature altitude (55,000 feet MSL) was forecast to shift from 250 to 270 degrees, which usually warmed things up somewhat. The cold air in the stratosphere lies to the south, above New Mexico. In the X minus one day briefing, -70°C was considered the temperature which would preclude the flight. A special radiosonde run just prior to layout indicated -69°C. The actual minimum temperature during Lt McClure's ascent, was -68°C at 55,000 feet MSL, or 97 millibars.

The jet stream, though active in Minnesota by this time of the year, was still far north of New Mexico. Maximum wind encountered by the balloon was 36 knots at 60,000 feet MSL.

In general, the meteorological conditions were probably more ideal than for any manned stratosphere balloon flight in history. The surface winds at touchdown were almost as light as during the launch. This landing, after twelve hours flight

time, occurred only twenty miles from the launch site. The balloon could be easily detected without optics, right up to sunset.

Figure 29 analyses the floating altitude trajectory.

The Canadian trough was still moving gradually southward, and it would soon be expected to generate New Mexico's prevailing southwesterlies for October and November. For a day or so, however, the protruding Bermuda High would have been another important factor, fluctuating the New Mexican flow from 160 to 220 degrees. As the delay of the launch would have resulted in an invasion of the Canadian trough, the ground tracking vehicles were positioned as far northeast as Amarillo, Texas.

Another argument for positioning the ground vehicles east of the Sacramento Mountains, rather than lining up for 160 degree flow, was the mountains themselves. It is a little known fact that even in the high stratosphere, air trajectories are modified by mountain blocks. As a rule of thumb, in the Holloman region, we find that if the flow is less than 15 knots at 100,000 feet MSL, a balloon upwind of the mountains will be deflected. The flight could either be prevented from crossing the range for a full day, or be delayed many hours.

By X -12 hours however, the Bermuda High had unexpectedly intensified. A radiosonde run to 115,000 feet MSL revealed easterlies all the way to the top. The situation was markedly anomalous for this season. A typical run would have pivoted from southeast at 8 knots at 90,000 feet, to southwest at 30 knots at 115,000 feet.

At this time the network of tracking ground vehicles was drawn back nearer to the Base.

Two hours prior to launch, a radiosonde run indicated 140° at 8 knots at 100,000 feet. This low speed was sufficient for the mountain block to effect the trajectory for most of the first day. At that time, it appeared logical to continue to hold the ground vehicles east of the mountains. However, from the flight itself we learned that the speed of easterlies is generally faster than indicated on the early morning radiosonde runs.

The climb-out winds were a variable which contributed further to the failure of the mountain block. They decreased rapidly, and proved to be slightly slower than forecast. The flight consequently attained floating altitude directly over the

Sacramento Mountains, rather than just upwind of them (Fig. 30). Furthermore, the flow at cruising altitude had increased from 8 to 15 knots. This combination of circumstances nullified the expected block.

Over the middle of the basin however, after two hours of float, the balloon had slowed down to 11.5 knots. There were a few segments of southward deflection by the lower San Andres Mountains west of Holloman. This indicated that if the speed at floating altitude had been a few knots less, and the flight had reached float upwind of the Sacramento Mountains, the balloon would have spent at least half the day blocked by the higher Sacramento Mountains.

There were even higher and more extensive mountain ranges to the west of the San Andres which would have provided definitive blocks even with the 15 knots. Furthermore, a drop to 80,000 feet after sunset would have deflected the balloon northward; this actually occurred during descent (note 1605 MST on Fig. 30). Accordingly, the vehicles were kept north and slightly east of the balloon.

In retrospect, the AFMDC radiosonde run six hours prior to the flight, reported 138 degrees at 11 knots. Until modified by the San Andres mountain block, MANHIGH III floated at 120 degrees at 15 knots. A run from Edwards AFB during MANHIGH III floating time, compared with another at X -4 hours, indicated a definite northward shift of the Bermuda High. This fits nicely with the shift over the Tularosa Basin from 138 degrees to 120 degrees, i.e., from the nose of the protruding high, toward the southern perimeter.

3. <u>Balloon Performance</u>

a. Floating Altitude.

The 1.5 mil, three million cubic foot balloon weighed 1,010 pounds. The total load below the balloon weighed 1,819 pounds for a gross load of 2,829 pounds. Employing the ICAO 1954 Standard Atmosphere, upon which most balloon manufacturer curves are currently based, this dictates a theoretical floating altitude of 98,857 feet MSL, or 11.67 millibars pressure.

The ICAO Standard Atmosphere assumes a temperature of -41°C at this altitude. The 0415 MST AFMDC rawinsonde run indicated -44°C. A second rawinsonde run, in the air when the balloon attained peak altitude terminated at 85,900 feet MSL. It suggested a warming trend however.

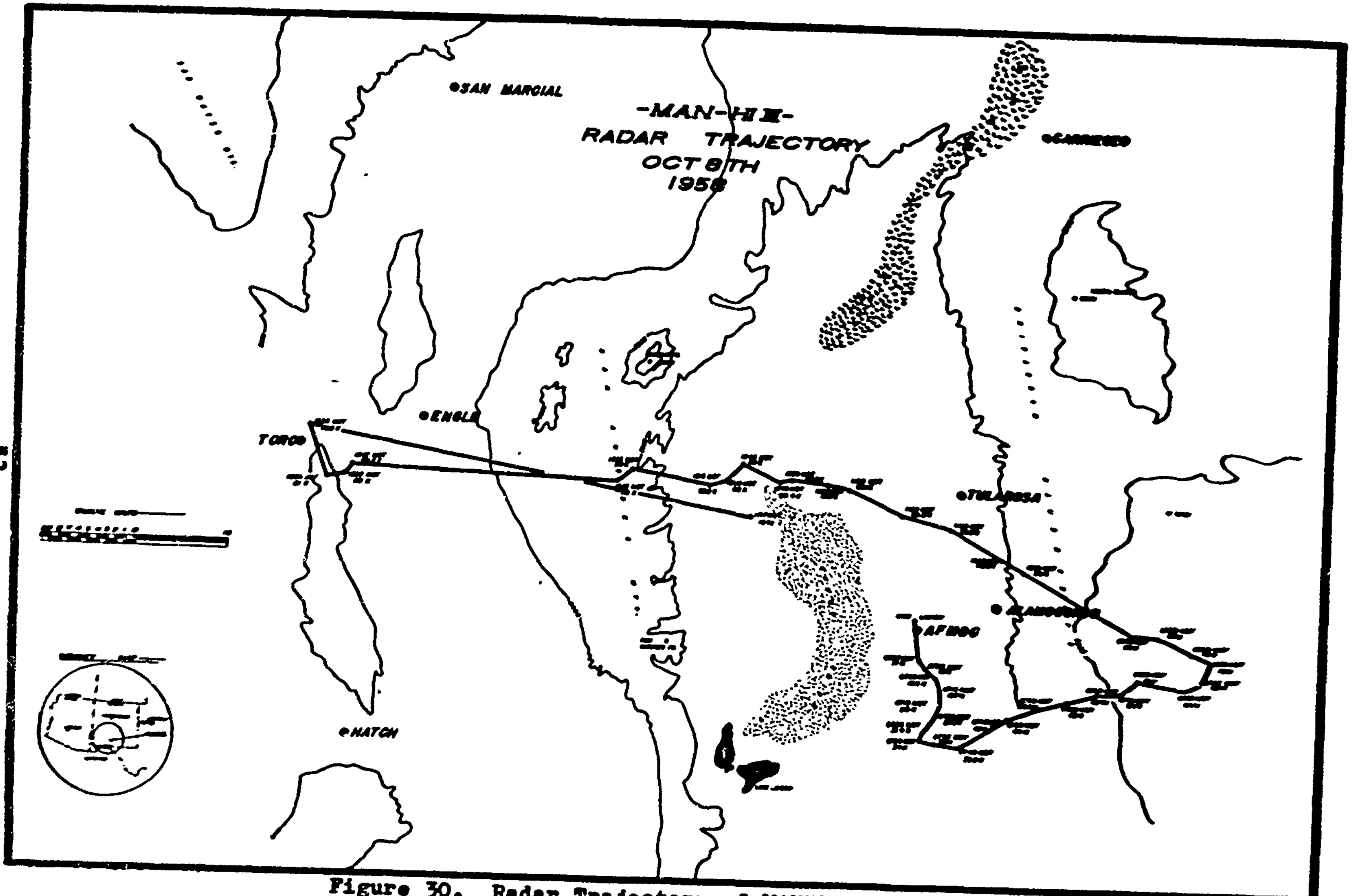


Figure 30. Radar Trajectory of MANHIGH III

Two rawinsonde runs from Edwards AFB, prior to, and during the flight, did attain 100,000 feet, and were sketched in with the AFMDC runs. They demonstrated a parallel warming trend. Extrapolating the temperature on the second AFMDC run with these guides, we arrive at an ambient flight temperature of -37°C.

Using -37°C, and assuming the helium to be 100 percent pure, the computed pressure altitude is 11.9 millibars. For -44°C it would have been 11.5 millibars, a difference of only 700 feet.

This assumes that the helium temperature was equal to ambient. Adding ten degrees centigrade superheat, a reasonable increment for polyethylene balloons at altitude, generates 11.8 millibars for the -37°C case, a difference of only 160 feet.

Referring once more to the ICAO Standard Atmosphere, we find 11.8 millibars at 98,388 feet MSL. The 0415 MST AFMDC rawinsonde run gives 99,050 feet MSL for 11.8 millibars. A pressure-height curve averaged from 20 runs for AFMDC for the month of October equates to 98,350 feet MSL for the same pressure.

The radar indicated a peak altitude of 99,900 feet MSL, at the conclusion of the valving period (Fig. 31). The balloon was over the Sacramento Mountains at this time, however. Consistently, a deviation in balloon altitude has been noted here. The constant density surfaces are apparently lifted over the mountains. Thus the balloon would achieve a geometric altitude peak here, but as expected, there was no definitive pressure altitude peak registered on the gondola altimeter.

Drifting off the mountains, the flight descended 900 feet below peak in the down wash. It stabilized at 99,150 feet MSL radar altitude for an hour over the valley. This most likely represents the undisturbed height of the constant density surface.

The optical network of the Integrated Range, which is amazingly accurate (readability at this altitude was one foot) indicated that the radar was 300 feet high. The geometric floating altitude therefore, should be corrected to 98,850 feet MSL. This corresponds to 11.86 millibars on the 0415 MST AFMDC rawinsonde run, a difference of only .06 millibars from the computed theoretical altitude which assumes 10°C superheat.

Since the altimeter could easily have been .3 millibars off at this altitude, 11.85 millibars appears to be the best estimate for the actual floating altitude of MANHIGH III. The atmospheric density at floating altitude would be 18 grams per cubic meter.

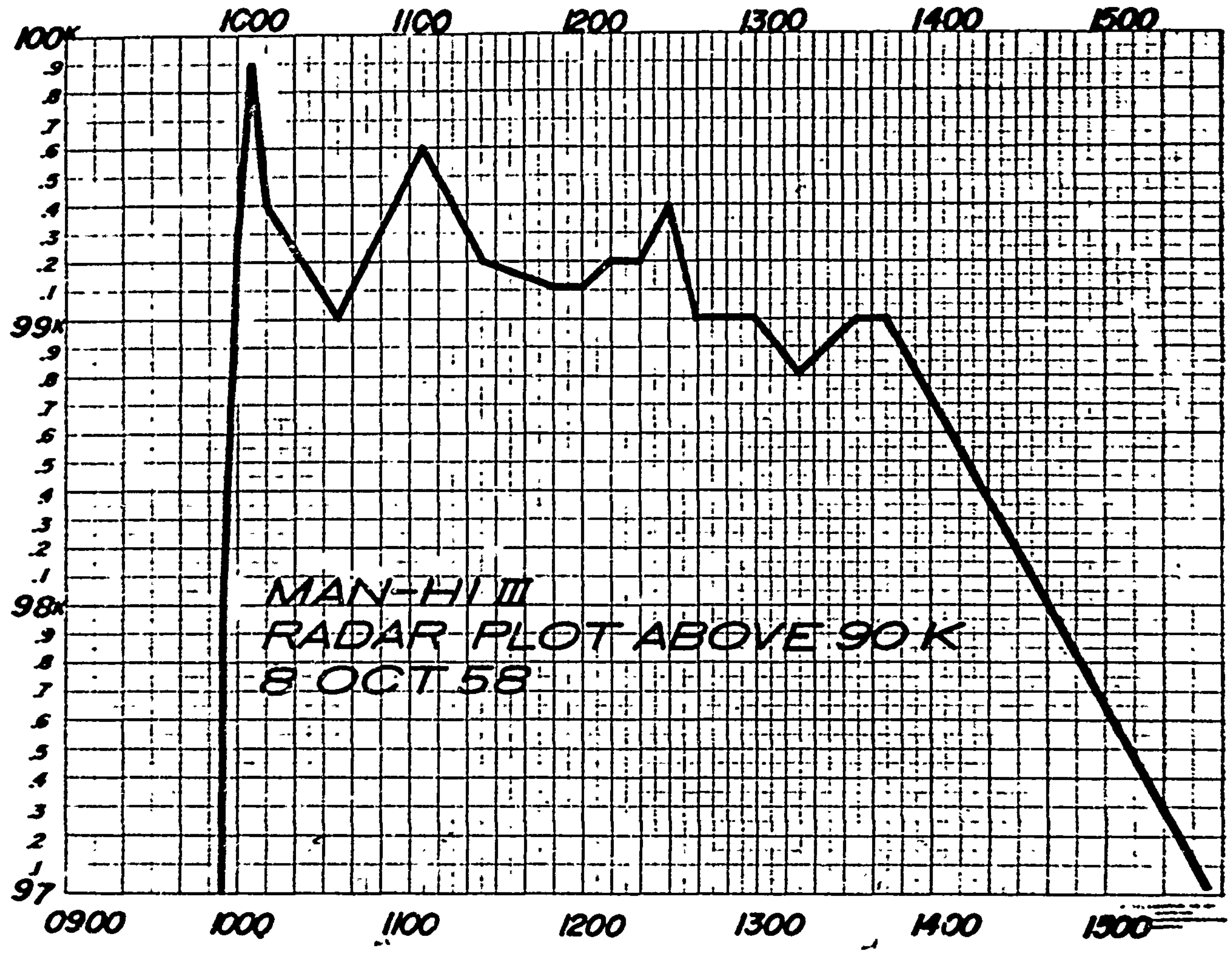


Figure 31. Radar Plot Above 90,000 Feet

TABLE I

SUMMARY OF BALLOON ALTITUDE MEASUREMENTS

	Millibars Pressure	Feet MSL Standard Atmosphere	Feet MSL AFMDC Run 0415	Feet MSL Radar (corrected)
Radar Floating Altitude	11.86	98,280	98,850	98,850
Theoretical, Standard Atmosphere	11.67	98,857	99,460	
Theoretical with -37°C	11.9	98,210	98,750	
Same with 10°C Balloon Superheat	11.8	98,388	99,050	
Radar Peak Altitude				99,600
Gondola Altimeter	12.15	97,750	98,350	

b. Ascent Rate.

The overall ascent rate for MANHIGH III was 504 fpm. It was 670 fpm in the troposphere and 400 fpm in the stratosphere. Four seconds of valving was performed in the troposphere but there was relatively little effect.

Ascent rate increments in the troposphere were beautifully correlated with the temperature lapse rate. Note the values for 5000 foot intervals.

Kilofeet MSL	Ascent Rate fpm	Lapse Rate (Degrees C/5000 feet)
5-10	670	9
10-15	680	10
15-20	680	11
20-25	770	13

25-30	800	12
30-35	770	9
35-40	490	6
40-45	570	6
45-50	560	7
50-55	400	4

Looking at the radar data more closely, we note that the maximum ascent rate occurred between 23K and 27.5K, at 900 fpm. This was also the location of the largest drop in temperature. At this time, wary of the increasing rate, a little valving was initiated. A closer look at the temperature spectrum prior to the flight however, would have indicated a natural maximum ascent rate at this level and perhaps delayed the decision to valve at that time.

c. Optical Data.

Figures 32 through 35 illustrate some of the amazing capabilities of the vast optical networks of the Integrated Range. It is beyond the scope of this report to delve into atmospheric periods of less than one second. However, the illustrations do highlight the potential of this type of facility for work in detailed aerostatics, and some idea of the stability of such a manned vehicle at altitude.

These runs commenced at approximately 1200 MST. Only in the first run was there an appreciable change in altitude, some 100 feet in 140 seconds. On the rest of the runs, the balloon demonstrated a maximum amplitude of oscillations of 34 feet, in 40 second periods.

On the one second samples, periods averaged three to four seconds. On the last sample, with five readings per second, there were smaller scale oscillations of .4 second. Maximum stability appeared to be about a three foot amplitude in four seconds.

A definitive analysis of these data will require rigorous coordination with the mathematicians associated with the Computer Division of AFMDC. Very roughly, accuracy at this altitude and position is about five to ten feet. Definition is, as noted, one foot.

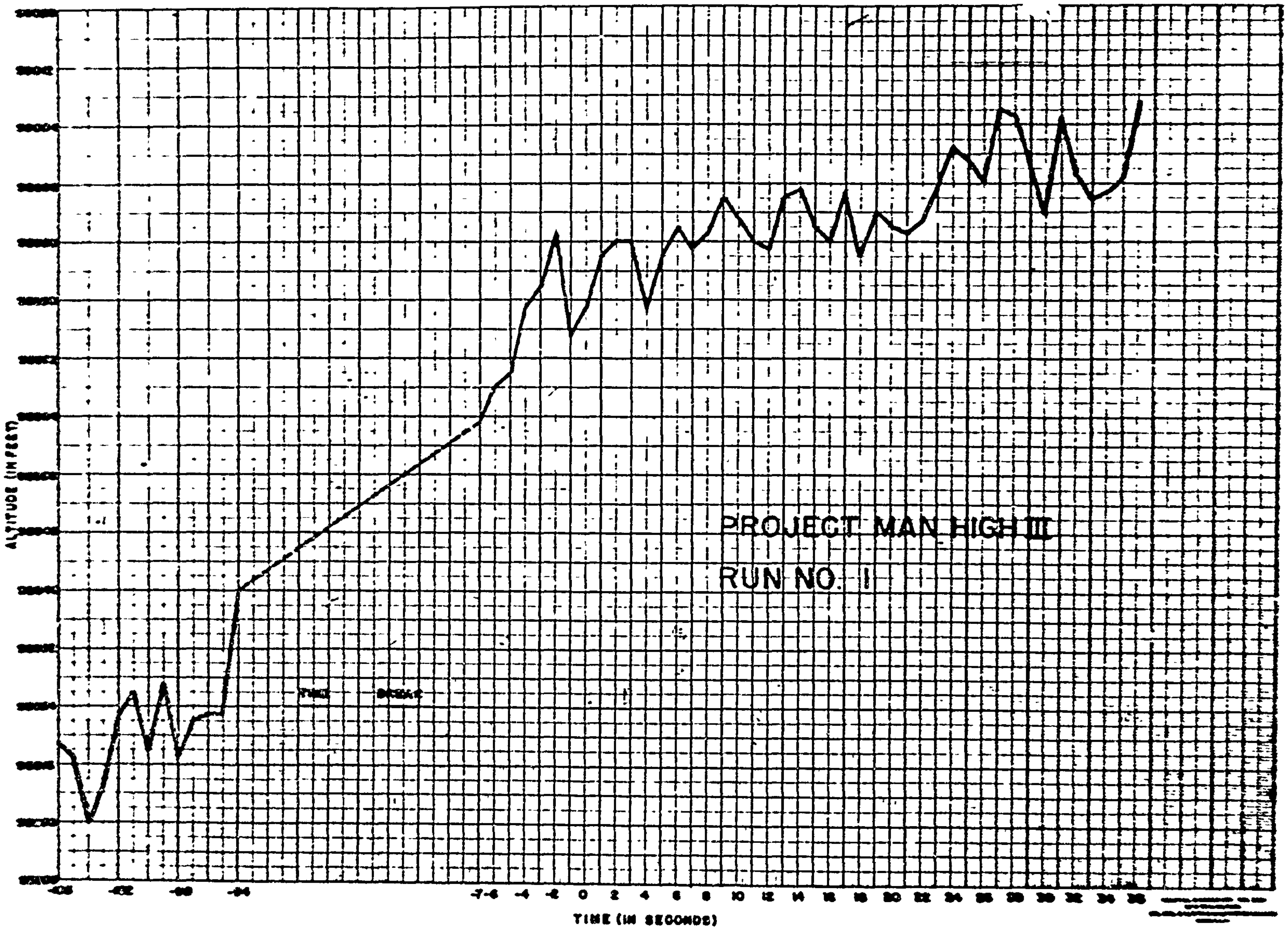


Figure 32. Oscillations of Floating Altitude Recorded by Range Optics (Askania) Run I

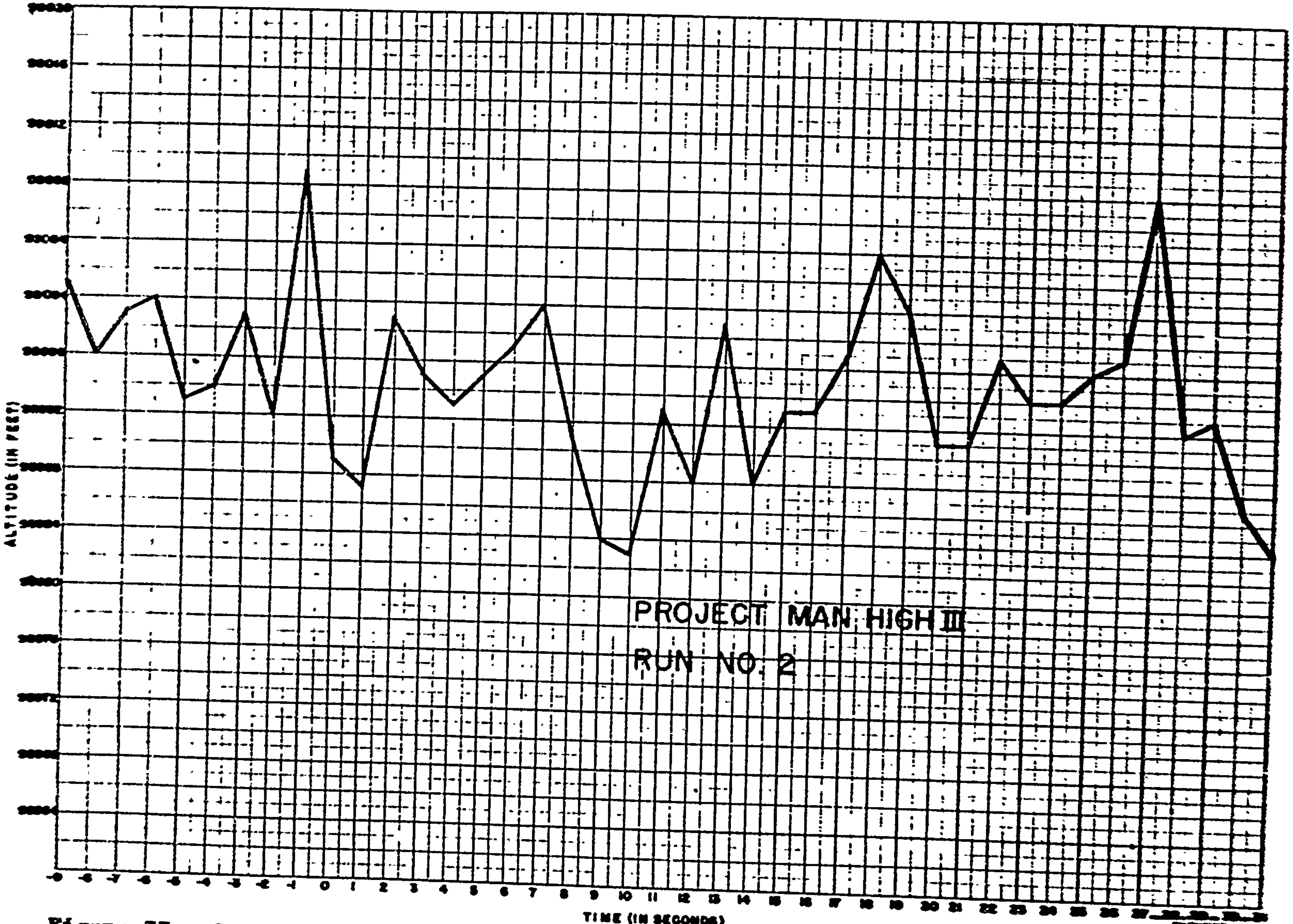


Figure 33. Oscillations of Floating Altitude Recorded by Range Optics (Askania) Run II

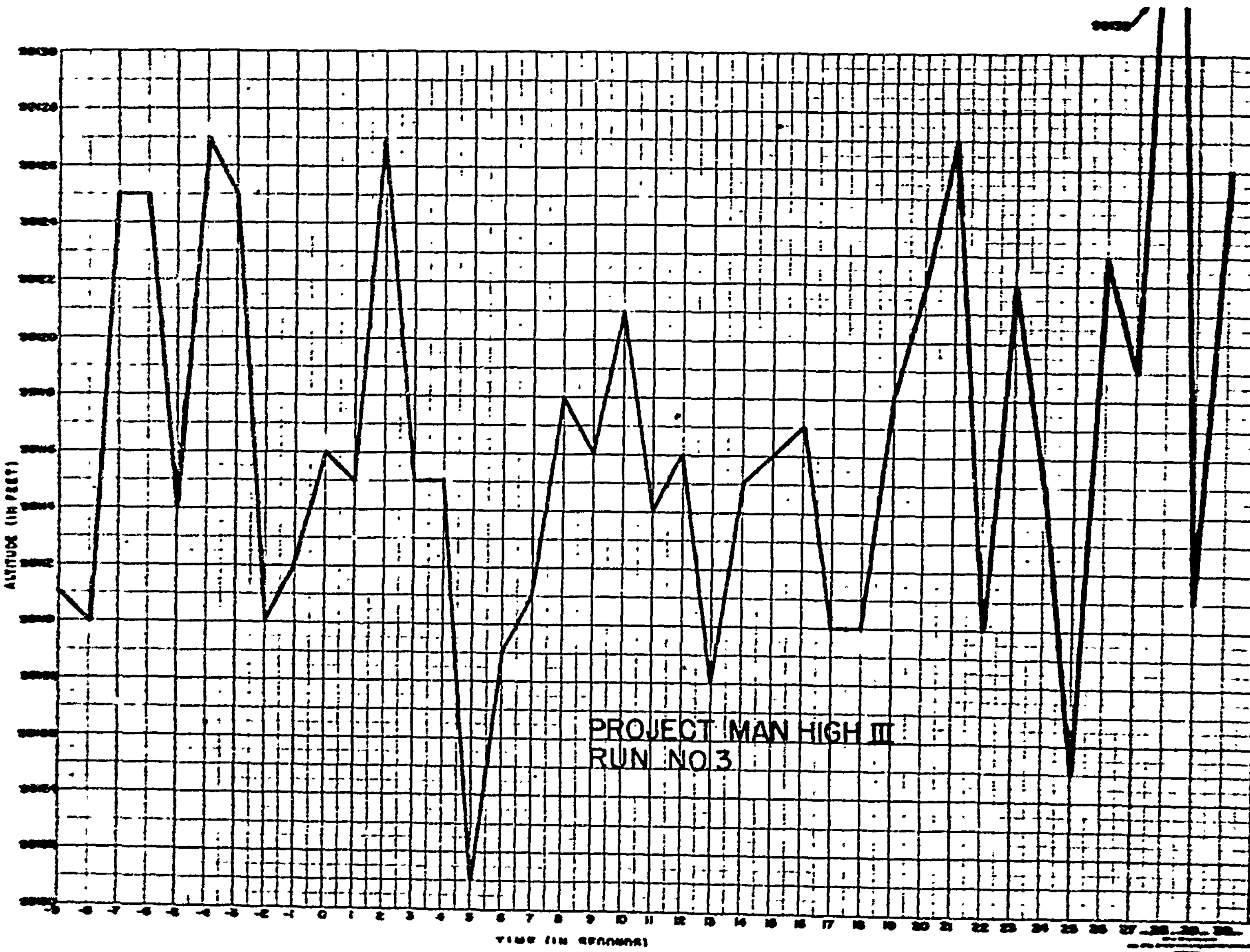


Figure 34. Oscillations of Floating Altitude Recorded by Range Optics (Askania) Run III

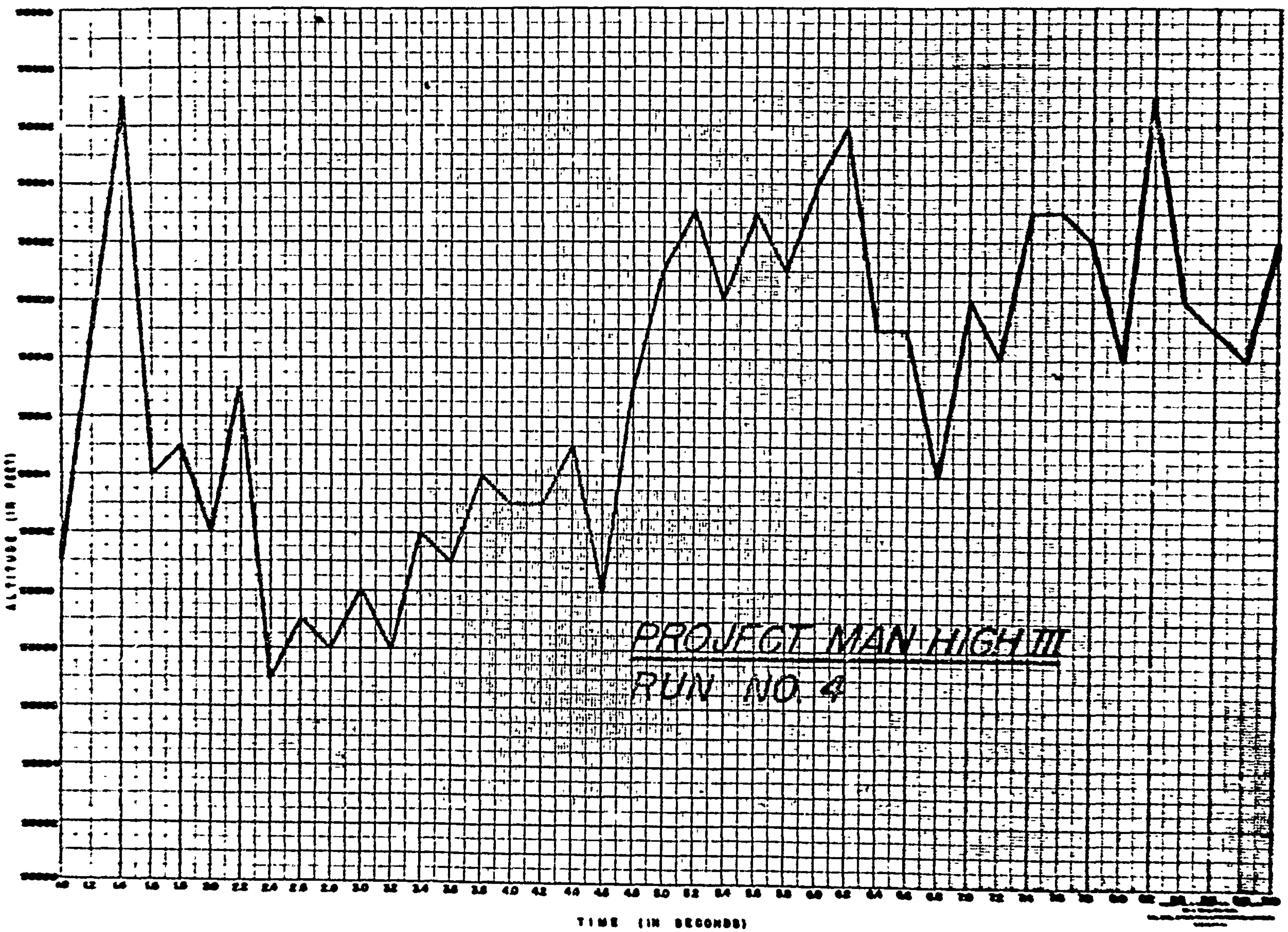


Figure 35. Oscillations of Floating Altitude Recorded by Range Optics (Askania) Run IV

ANNEX I

RADAR DATA OF MANHIGH III FLIGHT

TIME	AZIMUTH	HDO MILES	FEET MSL
0655	183°		
0657	177	5	11K
0700	171	6	13K
0705	163.5	7.5	16.5K
0710	163.5	9.0	19.7K
0715	166.0	10.5	23.0K
0720	170°	11.5	27.5K
0725	177	13.0	31.4K
0730	178.5	14.0	34.0K
0735	172	14.5	36.0K
0740	163	15.5	38.2K
0745	146	15.0	42.5K
0750	139.5	15.3	44.0K
0755	127.5	17.0	46.6K
0800	120.5	19.0	49.0K
0805	113.7	21.5	52.4K
0810	111.0	23.5	54.0K
0815	108.5	25.4	58K
0825	106.3	25	61K
0830	105	30	62.5K
0835	104	30.5	64K
0840	103.2	31.3	65K
0850	98.7	32.2	70K
0855	98.5	33.3	70K
0900	99	33.0	75K
0905	98.7	32.0	79K
0910	98.3	31	79K
0915	97.2	30	79.6K
0920	97.2	29	82K
0925	96.4	27.7	83K
0930	94.9	26.6	85K
0935	94.9	26.2	86K
0940	95.8	26	90K
0950	96.2	23.3	96K
0955	93.4	21.9	98K
1000	93.1	21.2	99.3K
1005	92	19.8	99.9K
1010	90.9	19.1	99.4K
1035	67.5	12.3	99K
1045	55	10.6	99.2K

ANNEX I (Cont'd)

TIME	AZIMUTH	HDO MILES	FEET MSL
1105	19.7	9.6	99.6K
1125	349.3	10.8	99.2K
1150	330	15.5	99.1K
1200	324.4	17.2	99.1K
1210	325	19.3	99.2K
1220	318.8	20.3	99.2K
1230	319	20.8	99.4K
1240	310.6	24.3	99K
1300	304.5	25.4	99K
[illegible]	301.5	26.8	98.8K
[illegible]	296.6	34.8	99K
1345	293.6	36.0	99K
1545	284.2	63	89.6K
1550	283.9	63.2	89K
1555	283.5	63.5	88K
1600	282.9	64.9	86.9K
1605	283	65.5	81K
1610	283.9	66.2	76.7K
1615	284.5	66.9	72K
1620	285.5	67.1	73K
1625	286.3	67.5	73.5K

ANNEX II

UPPER AIR DATA FROM RADIO SONDE
LAUNCHED 2-1/2 HOURS BEFORE MANHIGH III

Latitude - 32D 51' N	Date - 8 October 1958
Longitude - 106D 05'W	Time - 0415
Elevation - 4090 Feet	Visibility - 15+ Miles Cloudless

Height MSL in Ft	Wind Direction	Knots	Temperature Degrees C	Pressure Millibars	Density GM-M3	Relative Humidity
4090	Calm	Calm	13.5	874	1060	75
5000	M	M	17.0	845	1018	54
10000	M	M	17.7	814	980	41
15000	330	21	-1.6	584	752	MB out
20000	330	17	-13.2	481	643	
25000	360	17	-26.1	390	550	
30000	020	09	-38.3	315	469	
35000	260	22	-44.4	252	385	
40000	240	36	-50.4	200	312	
45000	250	43	-60.6	157	258	
50000	260	34	-64.9	123	206	
55000	270	31	-70.6	95	164	
60000	270	17	-65.3	74	124	
65000	250	08	-59.4	58	95	
70000	210	09	-58.6	45	73	
75000	190	04	-52.4	36	57	
80000	010	07	-51.0	28.5	45	
85000	090	14	-51.0	22.5	35	
90000	130	19	-49.0	18.0	28	
95000	130	12	-45.5	14.5	22.2	
100000	140	08	-43.6	11.5	17.5	
102907	130	07	-42.6	10.0	15.1	

CHAPTER III

SELECTION OF PROSPECTIVE PILOTS*

A. HISTORICAL REVIEW

The pilots for the MANHIGH I and II flights served as alternates for each other and were selected by the Chief of the Aeromedical Field Laboratory, Colonel J. P. Stapp, who required the following qualification procedure: (1) a Class I aviation flight physical, (2) physiological training in use of a partial-pressure suit at high altitude, (3) one parachute jump, (4) a Civil Aeronautics Administration balloon pilot's license, and (5) a 24-hour confinement test which included Captain Erwin R. Archibald's urine steroid study. Following the MANHIGH I flight, a 24-hour Wright Air Development Center low pressure chamber simulated flight test was added.

Following the philosophy of the previous two MANHIGH flights, the Project Officer, Lt Colonel Simons, recommended a pilot and an alternate to General Flickinger at Headquarters, Air Research and Development Command. At that time, the prime purpose of this flight was to obtain data for manned balloon capsule development anticipating more sophisticated MANHIGH research vehicles in the future. The prospective pilot, a civilian, who had engineering experience was related to the project through the contract and his alternate was an Air Force Aviation Physiologist.

At first, the requirements for MANHIGH III were those previously established for the MANHIGH I and II flights, with four differences. The requirement for a parachute jump was waived for the pilot in view of his civilian status. Secondly, a contract had been established with the David Clark Company to provide a modified partial-pressure suit to provide ventilation and relieve pressure points to make the garment more suitable for continuous use through prolonged periods of more than 24 hours. Each garment was individually fitted and tailor-made in order to provide maximum comfort. This fitting procedure had to be worked into the rest of the schedule. Thirdly, arrangements were made for Dr. D.V.L. Brown of Chicago to examine the pilot's eyes thoroughly before and after flight to detect any possible changes induced by heavy

*By Lt Colonel D. G. Simons and Captain C. L. Beeding, Jr.

primary cosmic particles. This required a preflight visit to Dr. Brown. Fourth, evaluation at Dr. George Ruff's Stress and Fatigue Section at the Aeromedical Laboratory, WADC,* was introduced for psychiatric interviews and psychological evaluation, including a subject terminated enclosure in the anechoic lightless chamber.

With the almost simultaneous disqualification of the first two subjects during the first week of June 1958, two new candidate pilots were introduced to the program. At this point, General Flickinger recommended that they be subjected to a selection procedure such as would be required for selecting an astronaut for satellite flight. The following additional selection procedures were introduced: (1) a preselection interview by the Project Officer, (2) a series of physiological stress tests, supervised by Dr. Charles L. Wilson, and (3) centrifuge tests supervised by Dr. Edwin P. Hiatt of the Aeromedical Laboratory, WADC. Since these new prospective pilots were relatively unfamiliar with the capsule, an added period of capsule familiarization was needed. Arrangements were made for Dr. Herman B. Chase of Brown University to examine each candidate preflight for comparison with postflight examinations to determine insofar as possible, the incidence of hair greying induced by primary cosmic particles.

With the disqualification of one of these two prospective pilots two weeks later, two additional candidates were introduced in the program and subjected to the selection procedure now established.

As subjects were eliminated for various reasons and replacements had to be found, available candidates were less and less acquainted with the program. The original two MANHIGH III subjects had been associated with the program through the MANHIGH I and II flights. The next two candidates had been assigned to the Laboratory through the period of the first two flights, but had not been directly associated with the MANHIGH project. Two candidates were essentially completely unacquainted with the project prior to their introduction to the program as prospective pilots.

One candidate had a degree in Ceramics Engineering, with a broad spectrum of keen interest in the field of science. Another candidate had had some engineering training and considerable practical experience with previous balloon flights.

*Now Wright Air Development Division (WADD)

Three were trained Aviation Physiologists, one at the Ph.D. level, except for completion of his dissertation. One candidate was a graduate psychologist with extensive experience in parachute testing of experimental personal equipment.

By the time the last two candidates were introduced into the program, the following requirements had evolved:

1. Preselection interview with the Project Officer.

2. Complete physical evaluation at Lovelace Clinic, Albuquerque, New Mexico.

3. High altitude chamber and partial-pressure suit indoctrination in accordance with AFR 50-27.

4. A 24-hour confinement (claustrophobia) test at Holloman Air Force Base.

5. Psychological/psychiatric evaluation under the direction of Dr. George Ruff at WADC.

6. Physiological stress response under the direction of Dr. Wilson and centrifuge response under the direction of Dr. Hiatt, WADC.

7. One parachute jump.

8. CAA balloon license.

9. A 24-hour simulated flight chamber test at WADC.

10. Capsule indoctrination.

Each of these selection and training procedures will be discussed as they were experienced by the six MANHIGH III candidates.

B. PRESELECTION INTERVIEW

The earlier candidates had been preselected by virtue of their familiarity with the program and their intense desire to make the flight. As it became necessary to look for candidates among personnel who had had no previous experience with the program, the need for a preselection interview became apparent. It was conducted to determine the motivation of the prospect, to examine the adequacy of his scientific background

and training, and to review his medical and family history, checking for any obvious medical contra-indications to his becoming a MANHIGH pilot.

Of these, the question of motivation was considered most important. An attempt was made to elicit the true reason the individual wished to be considered as pilot for the flight. Was the individual interested in proving something to himself, or about himself to others, or was he primarily motiviated to explore the unknown and advance the frontiers of scientific knowledge? Individuals with the former motivation would not only be more likely to fail under extreme stress, but would be much less likely to obtain an optimum amount of high quality research data.

The ideal pilot should have adequate physiological training to understand the capabilities and limitations of the human body in high altitude flight; have previous experience as a pilot, understanding pilotage; have a sufficient understanding of physics to comprehend not only how the capsule itself functioned, i.e., what actually went on "inside" when a particular knob or switch was operated in the capsule, but have a hobby acquaintance with the underlying physical principles of meteorology, astronomy, photography, and communications. These latter qualifications would be critical for optimum effectiveness of the panel of experts.

Specific medical contra-indications included such things as a history of claustrophobia, indications of emotional instability, and a history of episodes of unconsciousness.

In addition to the preselection interview, General Flickinger required that the candidate not have reached his 36th birthday. No limitation as to physical size was imposed, but one subject was nearly two inches taller and 15 pounds heavier (and much more heavily built) than the individual for whom the capsule was originally designed. He encountered serious difficulties repeatedly during the chamber flight and during capsule familiarization because of his large size. As a consequence, there was a serious question of his size being a grave hazard in the event of an emergency requiring an escape exit from the capsule. Figure 36 illustrates the tight squeeze required to fit him into the capsule.

The two individuals with strongly positive motivations had histories characterized by significant research accomplishments and an intense desire to learn more of the environment

Figure 36. Subject C Seated in the Capsule

and problems of living in space. One of these was eliminated because of an unexpected and purely physical problem, the other successfully accomplished the flight in the face of overwhelming difficulties.

With respect to the second factor in preselection breadth and depth of scientific background, none of the prospects had adequate training in all of the desired areas. In each case, it was a question of which factors were of greatest value and what areas needed to be emphasized in their training program. The Aviation Physiologists were prone to be weak in physics, astronomy, meteorology, and pilotage, while the engineering types tended to be critically weak in the aviation physiological area. This emphasizes the extreme importance of publicizing the need for broad scientific backgrounds in future astronauts and for establishing educational programs which will provide adequate training in the previously unrelated required disciplines ("cross-training").

The third factor in preselection, medical assessment and contra-indications, began with a general medical and family history. Each subject was assessed in terms of the aggressiveness with which he undertook unfamiliar and physically hazardous tasks. He was asked to cite an emotionally traumatic claustrophobic experience to determine the degree to which he has been able to withstand or not withstand enclosure and confined spaces in the past. Finally, he was interrogated for any specific contra-indications for making the flight as previously mentioned.

C. PHYSICAL EXAMINATION

In addition to meeting the requirements for an Air Force Class I flight physical, each candidate was processed through a four day evaluation procedure at the Lovelace Clinic, Albuquerque, New Mexico. The series of examinations was oriented specifically to the question: "Is this candidate qualified for the physical stress likely to be imposed by a flight of this type?" The type of examination had been developed through previous experience with the Air Force evaluating the fitness of pilots to undertake special missions. It included the following:

1. A thorough medical history.

2. A complete physical examination (including dental, sigmoidoscopic and proctoscopic), a complete eye, ear, nose,

and throat examination (including funduscopic, nasopharyngoscopic and audiogram), and electroencephalogram.

3. X-ray evaluation of teeth, chest, spine, and abdomen, including upper and lower gastrointestinal series.

4. Cardiac evaluation, including Double Masters Two-Step electrocardiogram and ballistocardiogram.

5. Pulmonary function tests, including nitrogen clearance, ventilation reserve, resting lung capacities, and maximum breathing capacity.

6. An exercise (bicycle ergometer) test rated as percentile of oxygen uptake per minute per kilogram body weight. During this test, the heart rate, systolic and diastolic blood pressures, and the oxygen-CO_2 gas exchange rates were carefully measured.

7. Complete laboratory studies, including gastric analysis.

8. Additional special examinations were added by the examining physician as indicated.

All six MANHIGH III candidates experienced this evaluation.

Candidate A was disqualified by the physical examination. He had a body weight in excess of normal for body size, combined with a positive Double Masters Two-Step of a definite type and a Ballistocardiogram of Grade III abnormality, based on Grades I to IV. Prior to taking his physical at Lovelace, Candidate A was known to have complete myopic astigmatism, sufficient that without corrective lenses, he would be unable to read dials and see controls in the capsule in the event of an emergency. For this reason, he had contact lenses fitted and was practicing using them so that he could wear them during the flight. Vision was 20/20 bilaterally with contact lenses. He wore them successfully during his parachute jump.

Candidates B, D, E, and F were all normal with the added observations that Candidate B had an unusually high exercise test rating and Candidate D had an exceptionally high maximum breathing capacity. Candidate F had a normal rating on his exercise tolerance test, but the test had to be discontinued because of elevated blood pressure, rather than elevated pulse rate, which is the usual response. In addition to the above examination at the Lovelace Clinic, Candidate D was meticulously

examined by Dr. Heinrich Rose of the Ophthamology Department of the School of Aviation Medicine for color vision. He was found to have completely normal color vision.

Candidate C was found to have a high frequency perceptional deafness secondary to acoustic trauma (undesirable but not disqualifying), a moderate red-green color weakness (very undesirable, but not disqualifying), a positive Double Masters Two-Step, and a Grade II abnormal Ballistocardiogram. His blood cholesterol level was high, 351 mg percent. He also was physically too large to fit well in the capsule.

For the above reasons, this candidate was returned to his home organization as physically disqualified for the flight. There a re-run of his Double Masters Two-Step was reported negative and his blood cholesterol reported within normal limits (later found to be associated with medication). Based on these observations, the positive Double Masters Two-Step and high blood cholesterol levels observed on initial examinations were considered transient observations and not disqualifying. Thus, the candidate re-entered the program and continued through his 24-hour WADC chamber run. Following this run (despite medication), his blood cholesterol was again above acceptable limits. Prior to this finding, he had been designated the pilot for the MANHIGH flight, but at this point he was redesignated standby or alternate pilot.

An additional study conducted through the Lovelace Clinic was a whole body gamma ray activity count at the Los Alamos Scientific Laboratory. This indicated the candidate's lean body weight and the gamma radioactivity level of body tissues, particularly radioactive potassium.

D. <u>PREPARATORY TESTS</u>

1. <u>High Altitude Chamber and Partial-Pressure Suit Indoctrination</u>

This is a training and indoctrination procedure which was prerequisite to the Skycar balloon training flights and the 24-hour flight-simulating chamber runs.

2. <u>Twenty-Four Hour Confinement (Claustrophobia) Test</u>

This test was established at Colonel Stapp's request as a requirement for qualification as a MANHIGH pilot. At

first, it consisted simply of confinement in a metal chamber the size and shape of the MANHIGH capsule with no tasks or physiological monitoring. After several runs, the opportunity for making physiological measurements became irresistible. Toward the end of the program, psychological tests were incorporated. Five such 24-hour tests had been conducted prior to those described here. Of the six candidates considered for the MANHIGH III flight, only three experienced this test. The third candidate who did not experience this test was being examined at the time when there was a profound sense of urgency to qualify candidates as quickly as possible. It was necessary, at times, to conduct tests when convenient, rather than in their logical sequence. This third candidate who did not receive the AMFL 24-hour confinement test was eliminated at WADC during the 24-hour chamber run for claustrophobia. It is most unfortunate that he missed this claustrophobia test since it would have helped greatly to establish its usefulness for this purpose.

Of the three candidates experiencing the 24-hour confinement test, one was given this test at the contractor's plant at Minneapolis, using the MANHIGH capsule itself. Unfortunately, the command van, containing the ground receiving equipment for the physiological telemetering circuits, was not available at the time of this test, so no physiological data were recorded on this subject. The transcription of communications between the candidate in the capsule and those outside during the test, indicates that he maintained a high level of performance with short periods of sleep throughout the run. His performance was entirely satisfactory.

The remaining two candidates, C and D, experienced this test at AFMDC. Captain Erwin Archibald, previously Project Physiologist, was responsible for development of most of the instrumentation used during this test. Dr. Harald von Beckh supervised the final checkout of the instrumentation system and assembled the protocol as used. He ably supervised the runs themselves.

The procedure for the tests called for the candidate to eat only a low residue diet for three days before the test. A protocol was established by Captain Archibald for obtaining blood and urine samples to evaluate the corticosteroid hormone excretion of the candidate to correlate this excretion with the stress imposed by the test. It required that the candidate have a fasting blood sample drawn the day before the test and that he start collecting all urine excreted each 12-hour period in separate containers. The urine sample collection continued throughout the test and three days following it with fasting blood samples drawn one day before and three days following the test.

The candidate was dressed in a partial-pressure suit which covered most of the torso with impermeable rubber bladders. He was then placed in the simulated capsule which was so positioned that he could hear or see no one directly, but could communicate to the operators through the radio system. While confined in the capsule for 24 hours, the candidate was required to perform three tasks which were evaluated in terms of time it took him to accomplish each task. The tasks required that he extinguish a small light, called the "panic light" whenever it came on; maintain a mock cabin pressure gauge at a prescribed reading; and indicate whenever an oxygen blinker meter failed to function at its usual frequency. Each task was administered at least twice every 30 minutes.

The following psychophysiological data were recorded during each run: electrocardiograph tracings, galvanic skin resistance, pulse rate, respiratory rate, and systolic and diastolic blood pressure.

Three items were evaluated every 30 minutes in an effort to assess the candidate's alertness: (1) degree of wakefulness (candidate's rating), (2) operator's evaluation of candidate (of the manner in which the candidate spoke and gave reports), and (3) attitude toward tasks (candidate's rating).

Degree of wakefulness was evaluated on a five-point scale defined as: (1) wide awake, (2) somewhat sleepy, (3) sleepy, (4) difficult to stay awake, and (5) unable to stay awake.

The operator's rating was rated on a five-point scale defined as: (1) bright, alert, precise, (2) reasonably alert, some sign of fatigue, (3) tired, flat, but coherent (obviously tired), (4) mumbling, halting, incompletely coherent, and (5) incoherent, trailing off.

The candidate's attitude toward his tasks were rated on a six-point scale, defined as:

Alpha - Thoroughly enjoying doing tasks - would like more of them.

Beta - Enjoying tasks, kept just busy enough.

Gamma - Prefer doing them - mildly enjoyable.

Delta - The number of tasks don't bother me or leave me particularly bored - I am indifferent.

Epsilon - Number of tasks causing some strain.

Zeta - This is too much - I am overloaded with effort.

At the conclusion of the tests, each candidate was given a careful physical evaluation and debriefed by those responsible for the test.

The results of the test of adrenal cortical response to stress are not yet available. The results of the two runs conducted in this manner showed revealing differences in the attitude and performance of the candidates. Examination of Table I shows that Candidate D consistently out-performed all other candidates with a more marked tendency to improve throughout the test period with some loss of performance efficiency during the third quarter. The oxygen blinker is probably the most sensitive indicator of the individual's alertness since it is the most subtle, requiring the greatest vigilance to detect the absence of the blink normally occurring once every three seconds. The superior performance of Candidate D as compared to Candidate C is especially marked on this test. The previous confinement test subjects, No. 1 and No. 2, are included in Table I for comparison only, and were not candidates for the MANHIGH III flight.

TABLE I

MEAN REACTION TIMES FOR CAPSULE TASKS FOR PERIODS OF SIX HOURS

	O_2 Blinker					Pressure Gauge					Panic Lamp				
	1st	2nd	3rd	4th	Avg	1st	2nd	3rd	4th	Avg	1st	2nd	3rd	4th	Avg
No. 1	32	25	66	68	48	17	22	25	20	21	4	5	6	2	4
No. 2		309	115	342	255	11	21	18	22	18	4	6	2	11	6
D	99	16	28	18	40	6	15	20	6	12	6	1	2	2	3
C	65	88	115	171	110	8	62	80	53	51	4	4	9	3	5

Figure 37 illustrates physiological data obtained for both Candidates C and D during their tests. There is nothing remarkable about the pulse rate of either candidate. The somewhat elevated pulse rate of Candidate D at the end of his run was likely due to this being overheated by having to wear the pressure suit at a temperature of 85 degrees with practically no ventilation caused by the failure of the blower fan motor.

The remarkably constant skin resistance values for Candidate D may be significantly related to his constant and high level of performance throughout the run. It correlates with this description recorded during the debriefing of his approach to the run:

> "Establish immediately a routine adequately covering the tasks required but requiring no additional effort and maintaining exactly this level of effort throughout the whole period, thereby conserving energy when feeling well to help carry over during the sleepy periods."

The steady increase in resistance of Candidate C suggests a steadily declining level of alertness and correlates with his declining total overall performance.

Figure 38 shows the return of both subjective and operator judgment ratings to higher values with sunrise of the second day. The prospect of termination of the test is correlated with increased performance scores or at least no loss of average performance which is characteristic of the fourth quarter for all candidates. The degree to which an operator's assessment and that of the candidates themselves agree in Figure 38 is noteworthy. It is also very interesting that both candidates rated their tests much more enjoyable at the end of the flight, probably because the accomplishment of them became identified with termination of the test.

The tendency for individuals to become irritable with prolonged sleeplessness is well established. When asked a leading question concerning his feeling toward the operator throughout the run, Candidate D replied with the significant comment, "Any operator (at the control console) that had some jest in his voice, a little bit of lightness, wasn't too appreciated". This reflects the deep seriousness with which this candidate approached all tasks required of him.

When asked about his general impressions of the test, he replied: "Well, when I started the test I knew the importance of the test itself, especially if I was going to be a subject

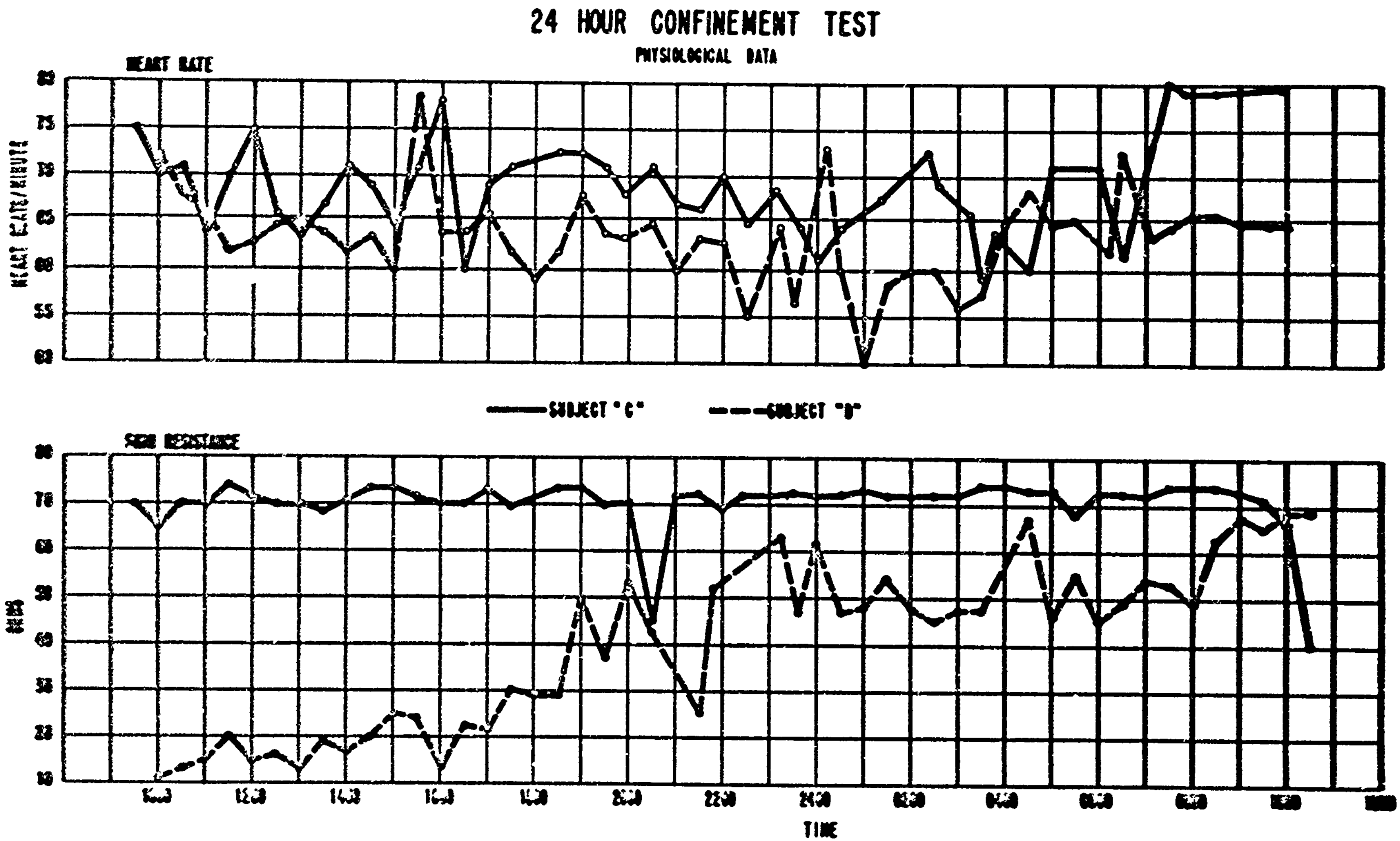


Figure 37. Physiological Data of Confinement Test (Subject C and D)

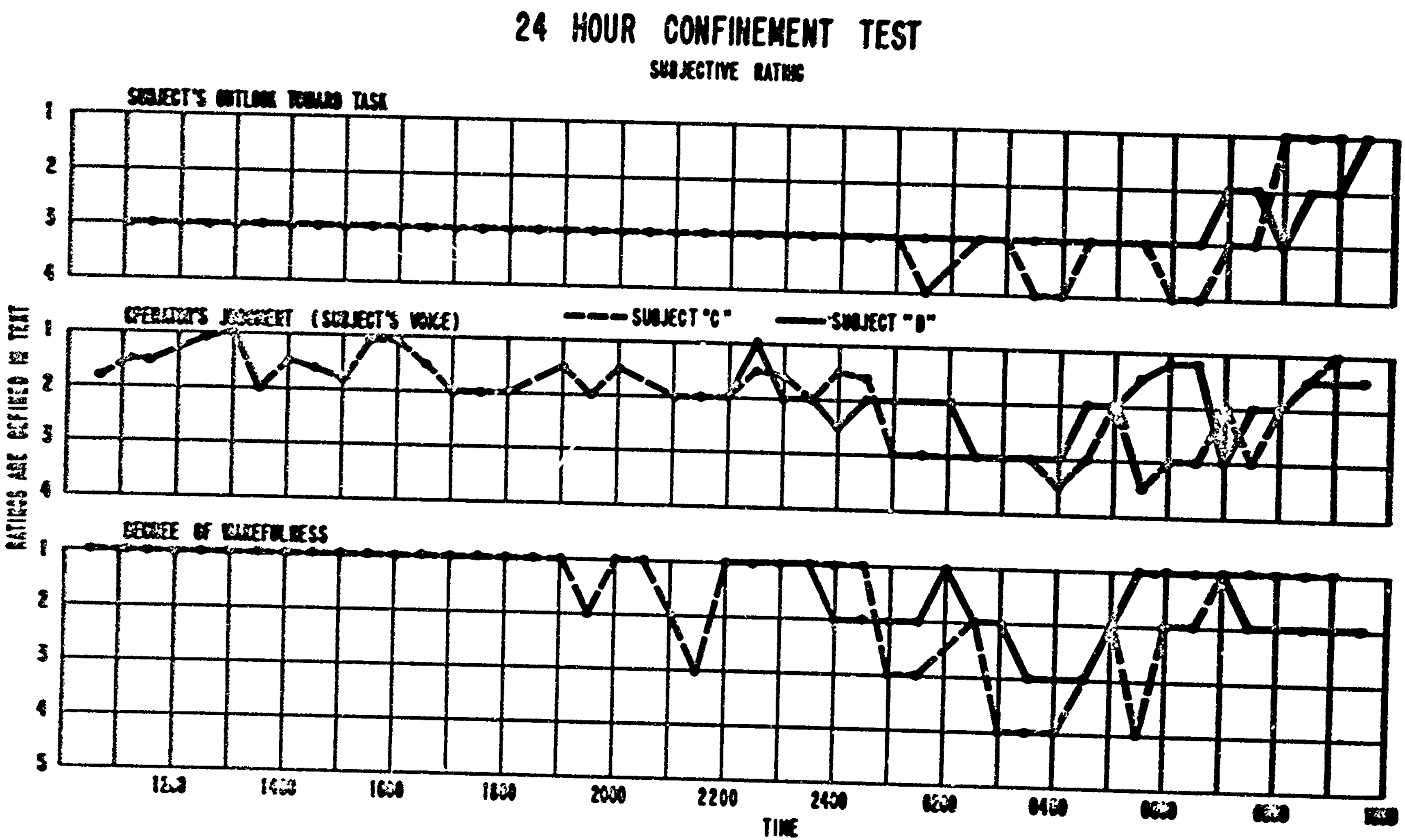


Figure 38. Subjective Operator Ratings During Confinement Test (Subjects C and D)

in MANHIGH. So I resolved not to force myself to take it, but since I had already stayed in the suit eight hours Sunday just for the practice, I figured it would be pretty easy, but after about the ninth or tenth hour, it was a totally different matter. It still wasn't a matter of whether you had to grit your teeth and bear it, hold yourself or anything, it was just a difficult job and you just had to sit there and do it. I never forced myself to do it, if I had had to, I would have come out of there because I don't think you should go on the MANHIGH flight when you are under that much strain". This is a profound commentary on the nature of this individual's motivation.

3. Isolation Stress and Psychological/Psychiatric Evaluation

The evaluation of each candidate carried out under the direction of Dr. George Ruff, Chief of the Stress and Fatigue Section of the Aeromedical Laboratory, WADC, included parallel psychiatric interviews by two psychiatrists, a clinical psychological evaluation, and placing the individual in isolation for as long as they were willing to remain. The psychiatric portion of the interview was done primarily to gain a clinical impression of the individual, his motivation (kind and degree), his psychodynamics, emotional maturity, emotional stability under stress, etc. The psychological test battery was selected to measure motivation and personality and included such tests as the Rorschach Test, Thematic Apperception Test, Draw-A-Person Test, and the Minnesota Multiphasic Personality Inventory.

The individual's response to isolation was evaluated by having him voluntarily enter a dark, sound-proof room, and stay as long as he could. The length of time that he remained, the degree of stress the test imposed, his manner of handling it, and the reasons for and manner in which he terminated the test were all considered in his evaluation.

A part of the psychiatric evaluation program included a psychiatric interview of each candidate every several hours during his 24-hour WADC simulated flight chamber run in a manner analogous to the interviews conducted during the actual MANHIGH III flight. The psychiatrist conducting the interviews on a given candidate during the chamber test, was expected to, and did, serve as a member of the panel of experts during his flight.

Candidate D ran through both the chamber run and isolation study without significant evidence of stress from a

psychiatric point of view. Candidate C, over 10 years older, had less of his youthful capacity to overcome all obstacles but demonstrated great stability. None of the four candidates evaluated psychiatrically were reported inadequate for the MANHIGH mission.

4. <u>Physiological and Centrifuge Stress Responses</u>

The physiological stress responses of four of the six candidates were measured. Captain Charles L. Wilson of the Physiology Branch, Aeromedical Laboratory, WADC was responsible for the tests and their evaluation. Although all of the desired tests available within the Physiology Branch were not included because of time limitations, the observations that were made were considered valuable. The stress tests began with a Harvard Step Test to insure adequate cardiac reserve to perform the subsequent procedures.

The MC-1, Partial-Pressure Suit Test, required that the candidate dress in an MC-1 suit, and MB-5 helmet, denitrogenate for two hours on 100 percent oxygen, then sit in the low pressure chamber which was evacuated to 42 millimeters of mercury (equivalent to 65,000 feet altitude). The candidate remained at this barometric pressure one hour (or less depending on various objective and subjective data). The ECG, blood pressure (indirect strain gauge), pulse, as well as suit and capstan pressures were recorded.

The cold pressor test required that the candidate plunge both bare feet into ice water and hold them there for a period of seven minutes while the pulse and blood pressure were recorded. An increase in both pulse and blood pressure has been considered by Dr. Terrence F. McGuire as advantageous and an expression of a responsive sympathetic nervous and hormonal system which more effectively maintains the body homeostasis.

The 30 mm Hg Pressure Imbalance Test was administered by having the candidate denitrogenate on 100 percent oxygen for one hour, then breath against 30 millimeters of mercury pressure at 40,000 feet wearing an A-13A mask breathing 100 percent oxygen. This test rates the individual's cardiovascular response to increased intrathoracic pressure, as well as mild hypoxia.

Three of the six candidates progressed sufficiently far in the program to experience this group of tests. A fourth

was eliminated at this point because of unfavorable reactions during the initial phase of these tests. All three candidates, C, D, and E, achieved average scores, ranging from 73 through 79 on the Harvard Step Test. Those in good physical condition routinely score 80 to 95, while those in top physical condition score 95 to 125, or rarely better.

The results of the cold pressor tests on each of the three candidates are presented in Table II. The response by Candidate C is a mild yet definite trend toward increased pulse rate and increased blood pressure considered favorable by Dr. McGuire. Candidate D evidenced a very dynamic response, starting with a somewhat elevated pulse, presumably from anticipation and terminally experiencing a quite high blood pressure. Candidate E was responding quite favorably by the end of the first minute of the test, at which time he withdrew his feet, complaining bitterly of the intense coldness and pain. This was only the second instance of interruption of the test by the subject because of discomfort in 100 subjects. The pulse and blood pressure response are considered favorable but the premature termination had unfavorable implications with respect to motivation.

TABLE II

COLD PRESSOR RESPONSE READINGS

Candidate	Resting Pulse	Response Pulse	Resting B/P	Response B/P
C	76	86	112/78	146/90
D	100	112	108/72	170/100
E	68	92*	118/78	130/96*

*Reading at end of one minute when candidate withdrew his feet, complaining bitterly of the intense coldness and pain.

Candidate C performed the MC-1 Partial-Pressure Suit Test very well with no appreciable change in pulse, blood pressure, or adverse symptoms or signs. He remained at 65,000 feet the required 60 minutes.

Candidate D started with a base line systolic blood pressure of 110 mm Hg which maintained itself well during 54 of the proposed 60 minutes, and then suddenly dropped to 90 millimeters of mercury systolic and remained low on recheck. The base line pulse of 76 had increased to a maximum of 140. At the 54 minute point, the candidate had a very sweaty, slightly pale face, and in view of the hypotension and tachycardia, was considered to be in a presyncopal state. Prudently the test was terminated. This was interpreted as a poor response to the test. The candidate had a tachycardia considerably higher than had been seen in many months.

Candidate E started with a base line pulse rate of 84 which gradually increased to 108 at the end of 38 minutes at 55,000 feet pressure altitude. At the same time, he developed definite sweating, marked light-headedness, nausea, and a mild hypotension of 100 millimeters of mercury systolic. Because of these presyncopal symptoms and signs which experience had taught would lead to unconsciousness with continuation of the test, the test was terminated at the end of 38 minutes. This was considered a poor reaction to this test.

The 30 millimeter mercury pressure imbalance test was accomplished satisfactorily by Candidate C. The pulse change was less than 10 beats per minute increase and the blood pressure remained steady.

Candidate D's test cannot be considered valid because it was terminated due to a burst of ECG waves which appeared on the oscilloscope to be of low ventricular origin (not written on paper). The test was immediately aborted. Although there is no good evidence that this was an arrhythmia, since the unusual pattern could have been caused by temporary electrode grounding, it was potentially a serious emergency and exploration of this possibility could not be pursued. At no time did the candidate demonstrate unusual symptoms, and close examination upon his return to ground level, revealed no evidence of abnormality.

Candidate E experienced an increase of pulse rate from 112 at ground level (not an unusual base line tachycardia for the uninitiated in the low pressure chamber) to 132 beats per minute. The blood pressure remained satisfactory and the candidate did not develop nausea, pallor, sweating, gunbarrel vision, or syncope. This was a good response and would have been rated excellent had the tachycardia not reached 132.

Candidate B was required to wear the MB-5 pressure helmet during the two hours of denitrogenization preceding the MC-1 partial-pressure suit stress test. On the first morning, while the candidate wore an A-13A oxygen mask for 1-1/2 hours prebreathing 100 percent oxygen, he became pale, sweaty, nauseated, and had two loose bowel movements, and finally retched. The test was postponed at this point to observe the candidate. There were no further symptoms of illness. Forty-eight hours after the first attempt at denitrogenization, the candidate was again available for test. He dressed in the MC-1 pressure suit and MB-5 helmet and denitrogenated for approximately one hour, at which time he decided he could not tolerate being confined in the helmet. He removed the helmet and refused to continue the test. It appeared to those monitoring the test that the candidate was unable to tolerate the confinement imposed by the pressure suit garment and helmet.

Candidates were exposed to acceleration on the human centrifuge under the direction of Dr. Edwin P. Hiatt, then Chief of the Biophysics Branch, Aeromedical Laboratory, WADC. Dr. Hiatt evaluated their responses. Three of the six candidates (B, D, and E) experienced this test. This was an initial exposure to the human centrifuge for all the candidates. Generally, candidates approach this awesome device with caution if not some trepidation and require repeated runs to become accustomed to it. Although the number and type of tests done are probably inadequate to make a real estimate of each man's response to centrifugation, none of the candidates showed evidence of unusually low tolerance to the acceleration experienced. Candidate E confirmed a known tendency toward motion sickness which did not seem to impair his G tolerance. Candidate D thoroughly enjoyed the experience, appearing disdainful, rather than awed by the acceleration, considering it a form of amusement.

In addition, a heat stress test, under the direction of Dr. Paul Webb, was included. All candidates experiencing it performed satisfactorily, although details are not available as to their performance.

5. Parachute Jump

This test was introduced into the program initially by Colonel Stapp to insure that the pilot would know how to use the parachute successfully with minimum danger of injury

in the event of an emergency. He considered it essential that the pilots have confidence and be sufficiently familiar with the parachute system to use it without hesitation should the requirement arise.

Four of the six candidates, namely, A, C, D, and E, successfully performed parachute jumps as required. Candidate F had this requirement waived and Candidate B did not progress sufficiently far in the selection procedure to experience this test. Candidate D jumped into the Salton Sea from an altitude of 6,000 feet, opening his parachute after a six second delay.

It is of particular interest that Candidate A made his jump wearing contact lenses with no adverse effects. Candidate C was already an experienced parachute jumper on active jump status and was not required to make an additional jump for this program.

6. Skycar Training Flight

This requirement was initially established by Colonel Stapp because he considered it essential that the pilot of the MANHIGH flight be familiar with balloon flight techniques before attempting a high altitude flight. He required that the candidates qualify for a Civil Aeronautics Administration free balloon pilot license. These requirements are: (1) a CAA medical examination, (2) successful completion of the CAA written examination, (3) 14 hours total free balloon flight time, (4) one flight to 10,000 feet or higher, (5) one solo flight in the presence of a CAA observer, and (6) six landings.

Only two of the six candidates completed the requirements for the CAA license, although all six of them received some Skycar training.

Balloon pilot training was conducted in the Skycar gondola which is a five foot diameter open basket constructed of steel tubing. It was normally flown with a 30 foot balloon which gave it a maximum altitude capability of approximately 14,000 feet. It could readily accommodate an instructor pilot and student pilot, with adequate space for a third observer. It was used specifically for training in free balloon flight techniques.

Candidate E had successfully completed all of the selection and training program with the exception of the final Skycar flight and part of the capsule indoctrination training

when he was critically injured in a Skycar flight accident. His injuries were of such a nature that he could no longer be considered as a pilot for the MANHIGH III flight.

7. Twenty-Four Hour Simulated Flight Chamber Run

a. General.

This test proved to be the most valuable single selection and training technique used in the program. It gave a clear indication of the quality of performance to be expected of the candidate on the actual flight and revealed problem areas in operational procedures, equipment, and emergency procedures.

The Chief of the Armament Laboratory made available the large refrigerated low pressure chamber located in that Laboratory at WADC. This was the only Air Force chamber known which was capable of accommodating the capsule and producing the -70°F temperature at 100,000 feet pressure altitude required to simulate space conditions. The cylindrical low pressure chamber was approximately 30 feet in diameter and 17 feet high, and readily accommodated the MANHIGH capsule which measured six feet in diameter, including its collapsible tubular supporting structure (the capsule itself was three feet in diameter) and approximately ten feet high, including under carriage.

The purpose of the chamber test was to simulate an actual balloon flight as realistically as possible. For this reason, the total time schedule was divided in a manner comparable to that of a flight. The activity-sleep pattern and total workload was also patterned after that expected on the actual balloon flight. The capsule atmosphere control problem, in terms of both composition and pressure regulation, was a true reproduction of the problems which the pilot would face at altitude.

The candidate was fully instrumented physiologically and required to make all subjective psychic reports and psychiatric interviews expected during the flight. Communication was by means of the same capsule radio which would be used on the flight. Physical data were transmitted by the same capsule telemetry radio which would transmit the heart beat (electro-cardiogram), respiration, basal skin resistance, and capsule temperature during the flight. This information was received on a telemetering receiver and written out directly on a brush recorder, using equipment loaned by Mr. Miles McLennan, Chief of the Instrumentation Section of the Aeromedical Laboratory, WADC. The candidate was monitored outside the chamber at all times during a run.

The Aeromedical Laboratory supported these tests fully, providing chamber operators to monitor the capsule. At all times two men were prepared to enter the chamber from a 30,000 foot intermediate lock in the event of an emergency. The laboratory also provided medical monitors, as well as personnel to operate the physiological monitoring electronic apparatus.

The candidate was required to make hourly reports, which included measuring and reporting the concentration of carbon dioxide within the capsule; the oxygen partial pressure; the instrument panel temperature; five points of capsule surface temperature; three physiological temperatures, including foot, thigh, and internal; and five subjective ratings of his psychic state, including alertness, drive, efficiency, tension, and comfort.

In addition to the above reports, the candidate was encouraged to make as many comments as possible to the dictet portable tape recorder placed beside him in the capsule. Although this was used during the chamber runs, a transcription of the material dictated to this tape recorder is not available at the time of writing this report. In addition, a camera was provided to take a picture of the candidate on 35 millimeter film every five minutes throughout the flight. The candidate was illuminated with filtered infrared light so that the flash was invisible, and recorded on infrared film. This permitted monitoring of the candidate's appearance throughout a chamber run and during the flight. This apparatus is described in another section of this report. Figure 39 illustrates the appearance of a subject taken with this unit.

The monitor outside the chamber was required to keep a running log of all noteworthy events, records of the pilot's hourly reports, including graphing of the pertinent data, and notes as to the condition of the candidate. Captain Eli Beeding, Project Physiologist at the time of the chamber runs on Candidates C, D, and E, supervised the monitoring and most of the time served as monitor of the chamber run himself. All conversations between the candidate and the monitor were recorded on a vox operated tape recorder.

The candidate was debriefed immediately after each chamber run to clear up any questions that had not been resolved during the run, and to elicit the candidate's feelings toward the simulated flight experience. These conversations were also tape recorded.

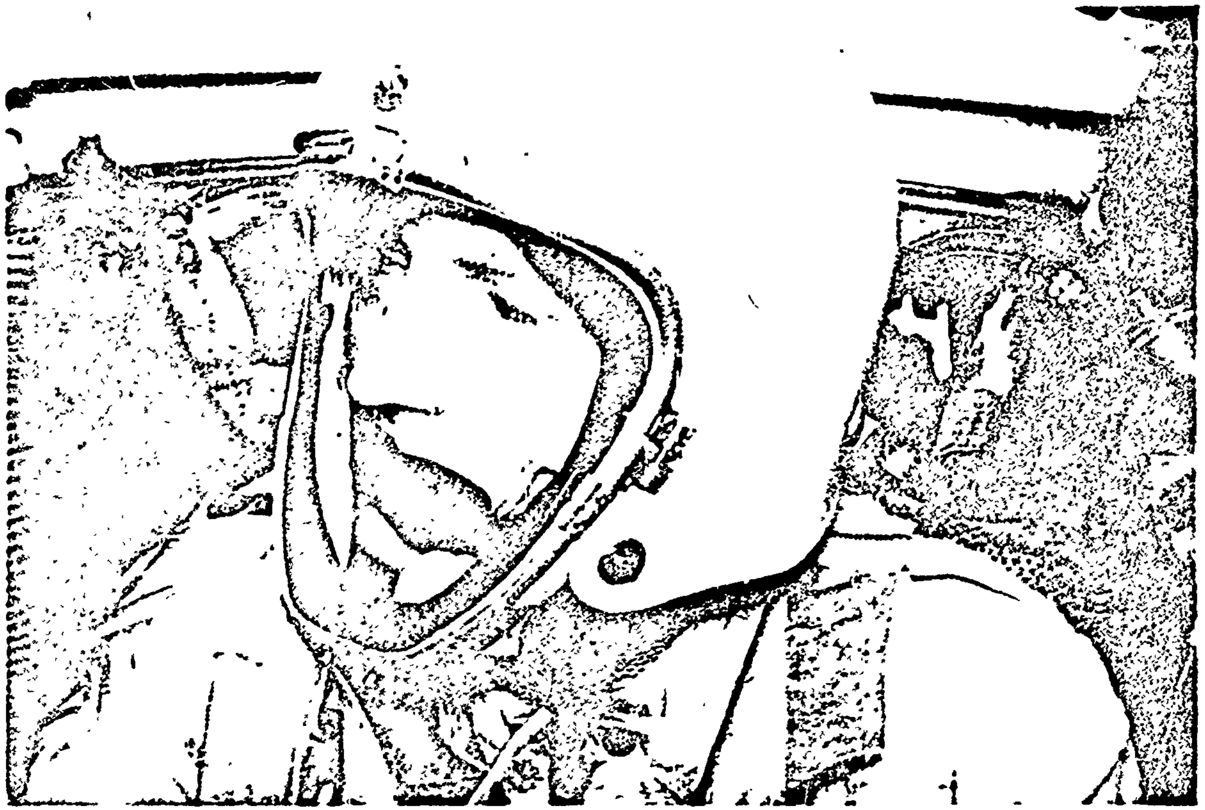


Figure 39. Infra Flash Picture of One of the Subjects During WADC Chamber Test

Of the six candidates in this program, three completed 24-hour chamber runs, C, D, and E, and one candidate, B, aborted a chamber run after 14 hours in the capsule. The candidates completing the test spent at least seven hours in the capsule before starting to altitude. This period was required to complete sealing of the capsule and to cold soak the chamber before going to altitude. Once the chamber approached the 100,000 foot level, the loss of heat conduction through air made it impossible to cool the chamber, but once chilled at ground level, the cooling coils were able to keep it cold while at altitude.

b. Candidate E.

This candidate had fully qualified in all selection procedures and was confident of making the flight at the time of this chamber run. At 1142 hours, the candidate had been completely dressed and began prebreathing oxygen to denitrogenate. This time was 12 hours out of phase from the time that he would be undergoing this procedure on an actual flight. This occurred for the convenience of sleep schedules of the candidate and the operators. The candidate commented later during the run that he had had only four hours sleep during the day preceding this run. He was sealed into the capsule at 1345 hours and the simulated ascent began at 2100 hours. Throughout the test, he was alert and interested in the scientific observations to be made and capsule operations procedures with the exception of the short periods during which he slept. For instance, he took a keen interest in comparing the performance of the experimental School of Aviation Medicine direct reading, two scale, oxygen sensor, comparing it to the standard Beckman unit. He rated this School of Aviation Medicine unit far superior in convenience and the ease and accuracy with which it could be read.

The reaction of Candidate E to the test is illustrated most clearly by quoting conversations between him and the psychiatrist when interviewed to evaluate his psychic state. At approximately 0900 (12 hours after simulated ascent), the following conversation was recorded between the interrogating psychiatrist and Candidate E:

INT (Interrogator): Hello. How's your back?

CAN (Candidate): It's a little better, George. I'll tell you what I did to relieve it. I brought a newspaper along which I was going to use for insulation and I folded it into sort of a square and I stuffed it down and put it in the small of my back now, and it helps me a little bit.

INT: That sounds like flexible adaptive behavior. Do you notice anything different now about your feelings now that you are in space and up there at 100,000 feet?

CAN: Yeah, George, now that I've been thinking about it here for a while, I think I'm a great deel more calm about it than I expected to be. Oh, it's a big thrill no less, but I think I'm beginning to act tired. I can look at things a little bit more objectively than when I was sitting down on the ground sweating out getting underway, if you know what I mean.

INT: Sure thing. Sounds good. Are you pretty wide awake, or are you a little sleepy?

CAN: Right at the present time, I'm a little sleepy. I got about four hours sleep last night and I think that's the reason.

INT: Sounds reasonable. I'll turn you over to the next man. See you a little later. So long.

About 1530, 6-1/2 hours later, the following conversation was recorded:

INT: The psyche people again. The last few times I've been interested in what you were doing. You answered all my questions just by doing some activity. That's why I haven't talked to you, but I thought now I'd better ask the usual questions, such as, "How are your spirits?"

CAN: Oh, spirits fine.

INT: How's the fatigue?

CAN: Uh, it's growing, George. I'm getting tireder by the half hour.

INT: Are you really having to push hard to stay awake?

CAN: Yeah, I find that I really would like to sleep at each (garbled) again.

INT: How are you able to concentrate?

CAN: Well, I just think about something else but sleep.

INT: Okay, fine. What sort of things have you been thinking about mostly?

CAN: Oh, ah, ah, things in connection with the project. Going to David Clark's for the pressure suit fitting, and going to see Dr. Brown and the things to be done from here on out, mostly.

INT: Well, sounds fine. See you later on.

CAN: Okay.

Up to this period, the candidate had been actively interested in operating the equipment on board for conducting the numerous experiments. For several hours through this period, his activity level reached a low ebb. He made his half hourly reports on schedule and responded immediately to all inquiries except during a few snatches of sleep. At nearly 2000 hours, some 23 hours after the beginning of simulated ascent, the following conversation took place:

INT: This is George. You look pretty strong from what I can see out here. How do you feel?

CAN: Just waiting for descent.

INT: You sound a little more lively than you did a couple of hours ago.

CAN: Yeah, I've got a second wind now, I think.

INT: How are your spirits now?

CAN: Fine.

INT: Anything you think important to tell me?

CAN: Uh, no, I'm looking for descent with anticipation because I'm trying to fight off a BM and I sure wouldn't want to try to tackle that in this capsule with this MC-3 partial-pressure suit on.

INT: Sounds like the best of motivation. Will get you down when we can. See you later.

The following comments were recorded during the debriefing:

INT: I want to ask you about the neck seal.

CAN: It was not only too tight, it was choking me.

During the run, Candidate E, had casually mentioned the discomfort of the neck seal several times. It was not until he took the helmet off after this debriefing that it was discovered that the original neck opening had never been cut open to his size, so that in fact it literally was choking him because it was several sizes too small.

INT: How did you feel in regards to being removed? Losing actual contact with people, being isolated?

CAN: No, I never really lost contact.

INT: How do you feel now?

CAN: I feel wide awake. The thing that I think was most constructive in thinking was because of the pain in my back that set in, oh, after the 24 hours I was in, and this was the thing that really got me to thinking. I had to get myself out of the fatigue I was feeling. If you will notice that towards the end there, I reported my drive was usually No. 3, but I was content to sit there and do whatever I was doing.

If the candidate was thinking that he had to get himself out of the fatigue he was feeling, by definition he was fighting fatigue. His subjective drive ratings illustrated in Figure 40, never fell below 3, although a No. 4 rating of "strong effort" was available to him. This tendency to overestimate one's effectiveness when fatigued is characteristic.

Upon undressing the candidate, it became apparent that the reason for the intermittent reception and unsatisfactory ECG telemetry signal was a loose electrode in the back. It had slipped completely out of its tape so that it was dangling within the suit.

The neck seal incident is a strong commentary on the intensity of his motivation. Throughout the run, he exhibited considerable ingenuity and spontaneous activity, e.g., he frequently asked questions concerning the operation of equipment and designed a makeshift solution for a maladjustment of the seat with paper available. Throughout the flight he came up with numerous suggestions of how to mount and arrange items in the capsule.

It is interesting to note that his foot temperature, presented in Figure 41 dropped and remained low throughout the

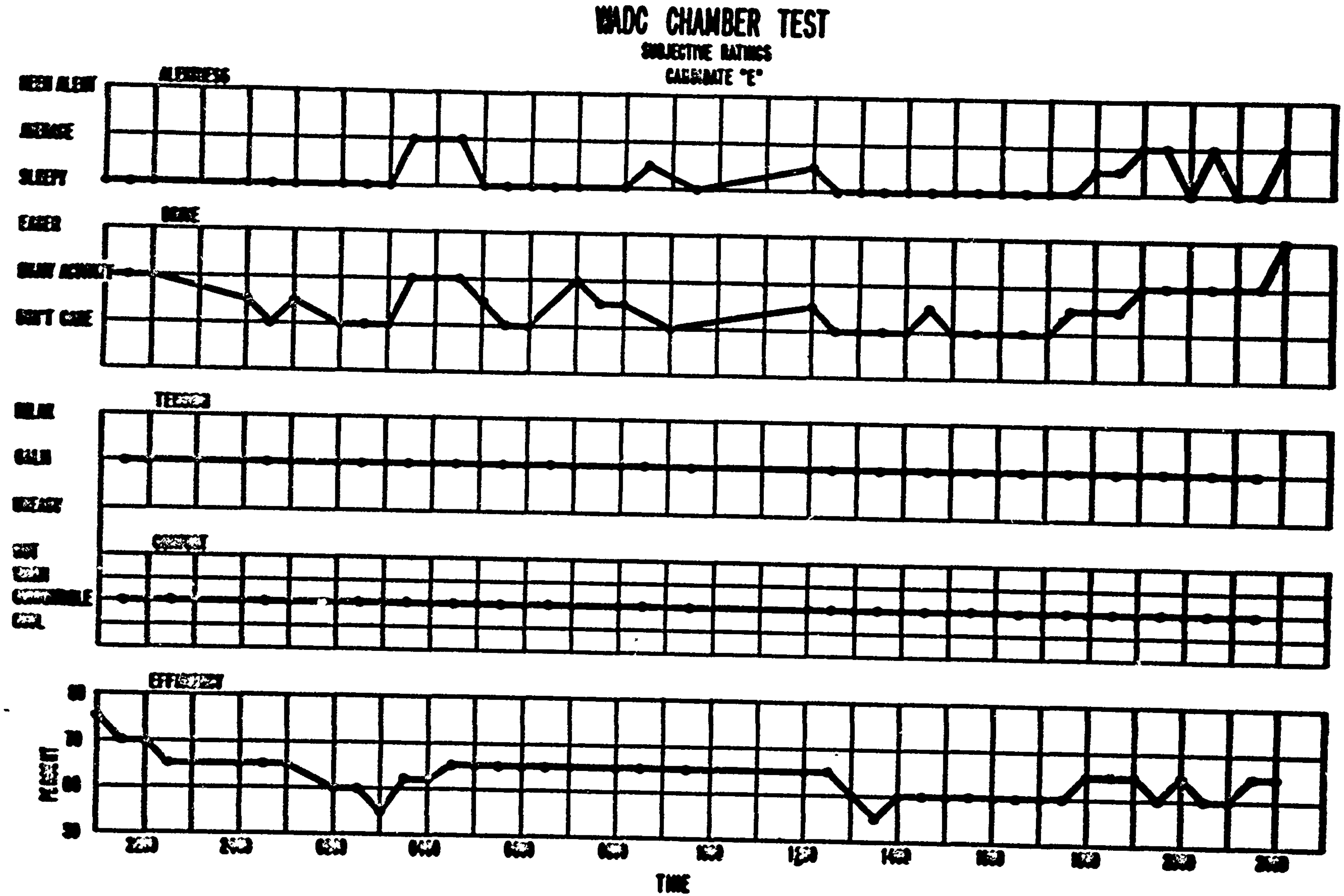


Figure 40. Subjective Operator Ratings During WADC Chamber Test (Subject E)

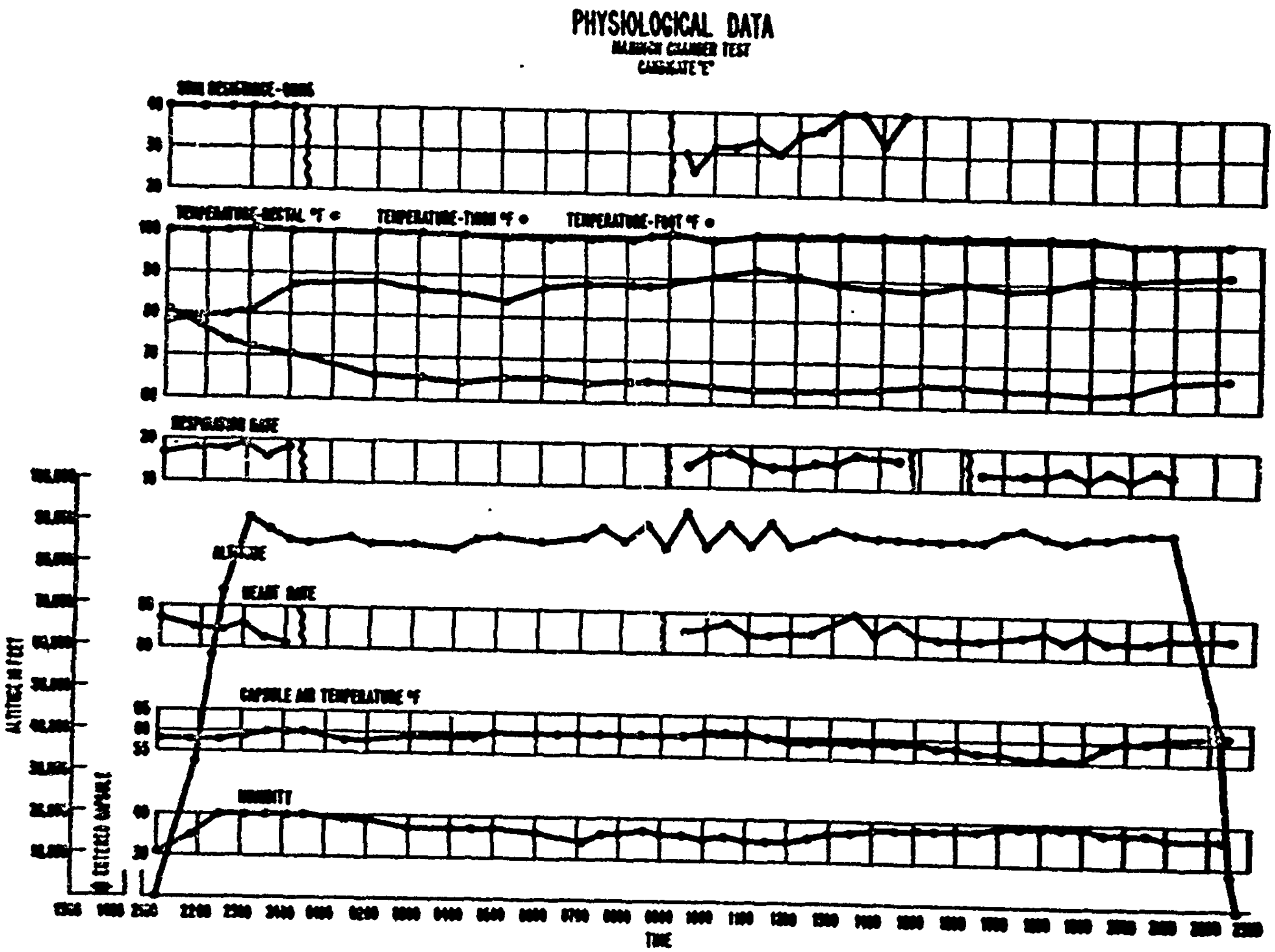


Figure 41. Physiological Data of WADC Chamber Test (Subject E)

run, while his thigh temperature gradually increased throughout the run in spite of a nearly constant capsule temperature. The foot temperature correlates with his comment during the debriefing that his feet were cold throughout the flight. Neither the respiration nor pulse rates are remarkable other than for their stability and moderate values. The subjective reports of Figure 40 indicate the marked stability and sensitive insight of this candidate.

c. Candidate C.

At the time Candidate E conducted his 24-hour chamber test, Candidate C was considered the standby pilot. Therefore, when Candidate E had his accident and was no longer available for the flight, Candidate C became No. 1 Candidate and Candidate D his backup. At the time of his WADC chamber run, Candidate C expected to make the flight. The two WADC chamber test runs described here for Candidates C and D were done one after the other with Candidate D considered backup alternate pilot.

Candidate C entered the capsule on 1 September and began the seven-hour preflight cold soak period. When ready to start the ascent the oxygen converter spewed liquid oxygen into the cabin, requiring that the run be aborted. It was discovered that the converter had been installed without adequate tubing between the converter and the suit connections. This discrepancy was corrected and the run initiated again the following day. By 1800 hours, Candidate C was dressed in his pressure suit and was sealed in the capsule. The ascent started at 0100 hours the following morning, approximately six hours ahead of an actual flight schedule.

The candidate's reaction to the situation is clearly illustrated by the following conversation between him and the monitor outside, recorded at 2000, several hours before ascent began.

INT: How did you feel when you started the test? Did you feel tired, or average, or what?

CAN: I wasn't as enthusiastic today as I was yesterday. Today I had the attitude that this was a job that had to be done and I was ready to do it, and I think I was a little more determined to get the damn test off.

At approximately 2200 hours, the last interview with the psychiatrist monitor went as follows:

INT: Hello, how are you?

CAN: Hi, Ed.

INT: Everything good in there? How are you feeling?

CAN: I feel all right. It's awfully warm in here. The temperature now is about 68 degrees and about 55 percent humidity, and I'm sweating as much as possible; it is still uncomfortably warm.

INT: Are you getting tired?

CAN: No, not yet. I fell fresh physically. I was just taking out the water when you called. I felt that I probably should be drinking some kind of liquid in order to keep up my body fluids.

INT: That sounds like a good idea. Did everything get started smoothly this time?

CAN: This afternoon everything went all right.

It is interesting to note that Candidate E reported a capsule temperature of 60 degrees throughout his capsule test and reported feeling comfortable throughout the simulated flight. Consistently, 68 degrees has been an uncomfortably warm temperature for the pressure suit in the capsule.

Frequently during this chamber test, there was a great deal of background noise in the radio communications circuit so that the monitor and the candidate had considerable difficulty understanding each other. This occurred during ascent when the time arrived for stabilization of the capsule atmosphere at an equivalent pressure altitude of 26,000 feet. Due partly to the difficulties in communication, the monitor on duty lead Candidate C through a pointless 15 minute exercise on manipulatingthe capsule pressure controls. Throughout this period, Candidate C passively followed the directions given him as best he could with no apparent effort to understand the nature of the problem or to evaluate the situation for himself.

Shortly before 0400, when the chamber had reached simulated ceiling altitude, the following conversation with the monitoring psychiatrist was recorded:

INT: This is Ed. Good morning.

CAN: Well, you got up early!

INT: How are you feeling?

CAN: Pretty good, Ed. We just got settled down. We had a little trouble, and I had one heck of a time getting into the parachute, getting the parachute harness on, etc., but now things are getting more normal and relaxed.

INT: You should be feeling pretty tired by now. Are you?

CAN: No, I feel fairly alert and efficient about this whole thing. I have a couple of pressure points on my helmet and that's the only thing that's bothering me. I wouldn't say that I'm tired yet.

INT: Well, good enough. Is there anything else about the way that you are feeling that you want to tell me?

CAN: Stand by a minute. I have been writing some stuff down here over a period of time, and I'll see if there is anything here. Everything is going real well, but now I think I'm going to start to get a little bit cold. It's 52 degrees in here, and I still have a long way to go. That's about all I've got, Ed.

INT: Do you feel pretty alert and able to handle any new situations that might come up?

CAN: As of now, yes.

INT: Do you feel any laziness as far as your thinking and actions?

CAN: None whatsoever.

INT: Okay. I'll see you about 8:00 o'clock then.

CAN: Okay. Goodnight.

Through the next 12 hours the candidate responded methodically to requests and commands, spending the usual amount of time having the monitor review emergency procedures. The 1400 hours pilot report was 17 minutes late. The 1500 hours report was 42 minutes late. There was no report at 1600 or 1700 hours. The 1800 hours report took the longest of all for

the candidate to prepare and transmit. By 2000 hours, he seemed to come back to life again. As can be noted in Figure 41, the 1800 and 1900 hour reports of this candidate indicated an efficiency level of 82 and 84 percent respectively. All other reports were in the nineties throughout the flight. The monitor's log contains a 1715 entry that the candidate reported an upset stomach.

At 2100, the candidate was told that he would start descent in four hours (at 0100). He had apparently figured out for himself that descent should start at 2300 hours as evidenced by the following comment recorded at 2400 hours.

INT: How are you feeling?

CAN: Oh. I was asleep.

INT. Sorry. I thought you were up.

CAN: Uhhh, well, I thought I was coming down a little sooner than I found out I was. That was kind of a disappointment. At the last minute I thought I was going to start down around 2300. Nobody told me this. I had to figure it out in my own mind. I find it's 1:00 o'clock, which is too long from now.

INT: You go ahead and get a little shut-eye.

During the debriefing, the following very revealing conversation was recorded:

INT: Do you want to elaborate any on how you felt? You have the impression that you were really having to push to do anything, especially that one pilot report you gave right along in there. It was real slow and your speech was sort of slurred.

CAN: Yes. I, this nausea that I had, I, now as I think back, the only thing that I can attribute it to, is the coffee drink. Because I think the records will bear out that there wasn't any particular anxieties at all, and this thing suddenly came on to me, and I was sick, and I wanted to throw up, but, of course, I couldn't, and I don't know whether I could have if I had tried, really, but I had that feeling, that I wanted to throw up, and this stayed with me for about four or five hours, and it got progressively worse, and then the thing that cleared

up was I slept, or at least I didn't do anything, for at least almost two hours, from about 5:00 until 7:00 and then I seemed to snap out of it.

INT: We purposely left you alone after that. Yeah. Quite a length of time.

CAN: Yes, it was a long time that you left me alone, I knew that, and again I wasn't sleepy, but I was, I had my head down, and I wasn't doing anything, and the lack of exertion seemed to help, but, why this came on all of a sudden, I don't know - one reason that I think maybe I got sick, was the procedure that had preceded the previous 36 hours or so. I had been in, I came out, I almost went back in again, I came out, I was in that pressure breathing for a long period of time. I went home and had not a good night's sleep. Back the next day, and then I had planned to sleep all afternoon when I thought we were going to be all day in getting this hose on, and I got about 45 minutes and then back here, and personally, I believe it was the buildup of all of these things and suddenly the bottom fell out from under me. Because all at once I had nothing at all to go on. If you hadn't let me rest, I don't know what would have happened. I was miserable - and while, to be very truthful about it, there was a while there when I was at that very, very low point when I thought, "Boy, I'm not too sure this is worth it and I'm sure that there is not a subject that ever goes in this test that doesn't experience the same thing some time in the thirty-some hours. My God, this is terrible!" But, when I bounced back and talked to Dr. Levy, what time, 9:00 o'clock - 7:00? - when I bounced back, then, I was determined that I was all right and there would be no problem particularly in finishing the test, but between 2:30 and 7:00 why, I wouldn't have bet a nickel on it.

INT: I was thinking the same way. I was real glad to see you bounce back.

The degree to which the candidate was emotionally dependent upon the monitor requiring his reassurance is clearly revealed in the following statement made during the debriefing:

CAN: There is one thing. If, I have to make this plain, I don't want to be presumptious. I mean, this is the history of this program. You don't want to be presumptious about making a hot flight, and this is no disrespect to anyone, 'cause, boy, I could have been washed out of here this afternoon

at 2:30 if someone had said, "Do you want out?" I would have said, "I want out." I mean, I was that close and I think this is the obligation of any subjects to be honest about your reactions in this thing and, boy, I was just about at the end of my rope but the point I wanted to make was that if I make this flight, I want one monitor on duty on that intercom with me all the time, because you make more sense to me than anyone I've ever talked to over that intercom. You and I seem to communicate real well, and I think it's just by your experience and your description when you say something I know precisely what you are talking about right away. Somebody else gets on there and says about the same thing and I have to stop and think. This, as far as I am concerned, is a must because you are the No. 1 boy on that communications if I go up. That's just about it.

The physiological data illustrated in Figure 42 reflects this candidate's highly stable unreactive nature. The skin resistance (if these are valid readings), heart rate, and respiratory rate are all remarkably steady. The foot temperature is particularly interesting for its continuous high level as compared to Candidate E. This doubtless is a reflection of the higher capsule temperatures and the fact that Candidate C felt hot during a major portion of the run.

The alertness and drive graph illustrated in Figure 43 confirms the impression obtained from the debriefing that the candidate had to "drag" through most of the test.

Despite the candidate's very low assessment of his effectiveness during the debriefing and the confirmation of his complete loss of effectiveness by the monitor, the candidate still rated himself greater than 80 percent efficient throughout the entire run on a 0 to 100 percent scale. This again emphasizes the difficulty individuals have recognizing at the time their low level of performance induced by fatigue.

d. Candidate D.

At the time of this chamber run, Candidate D was alternate pilot to Candidate C. As it later turned out, Candidate D made the MANHIGH III flight. This run was made after one day of rest for monitoring personnel following the chamber run of Candidate C.

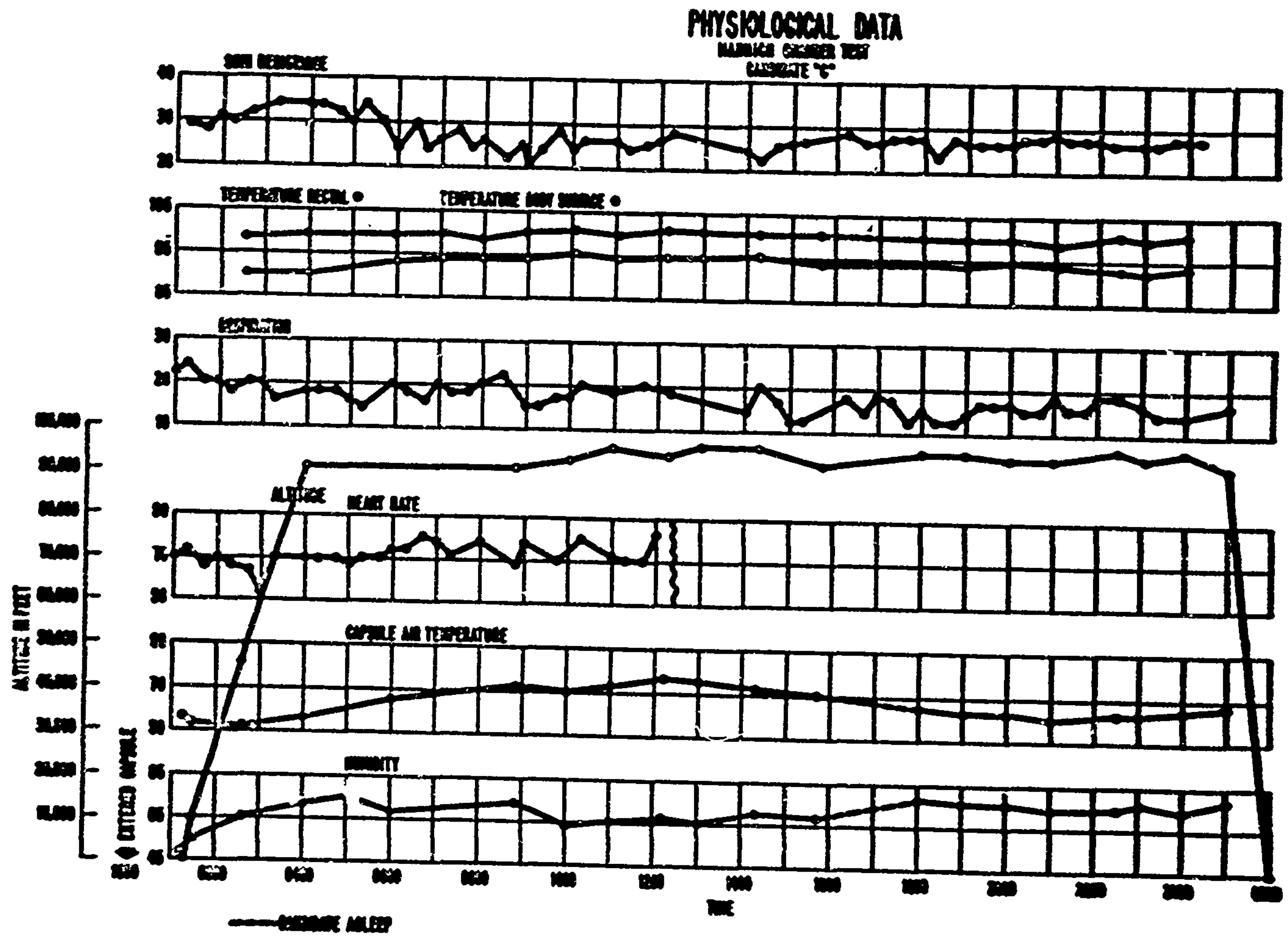


Figure 42. Physiological Data of WADC Chamber Test (Subject C)

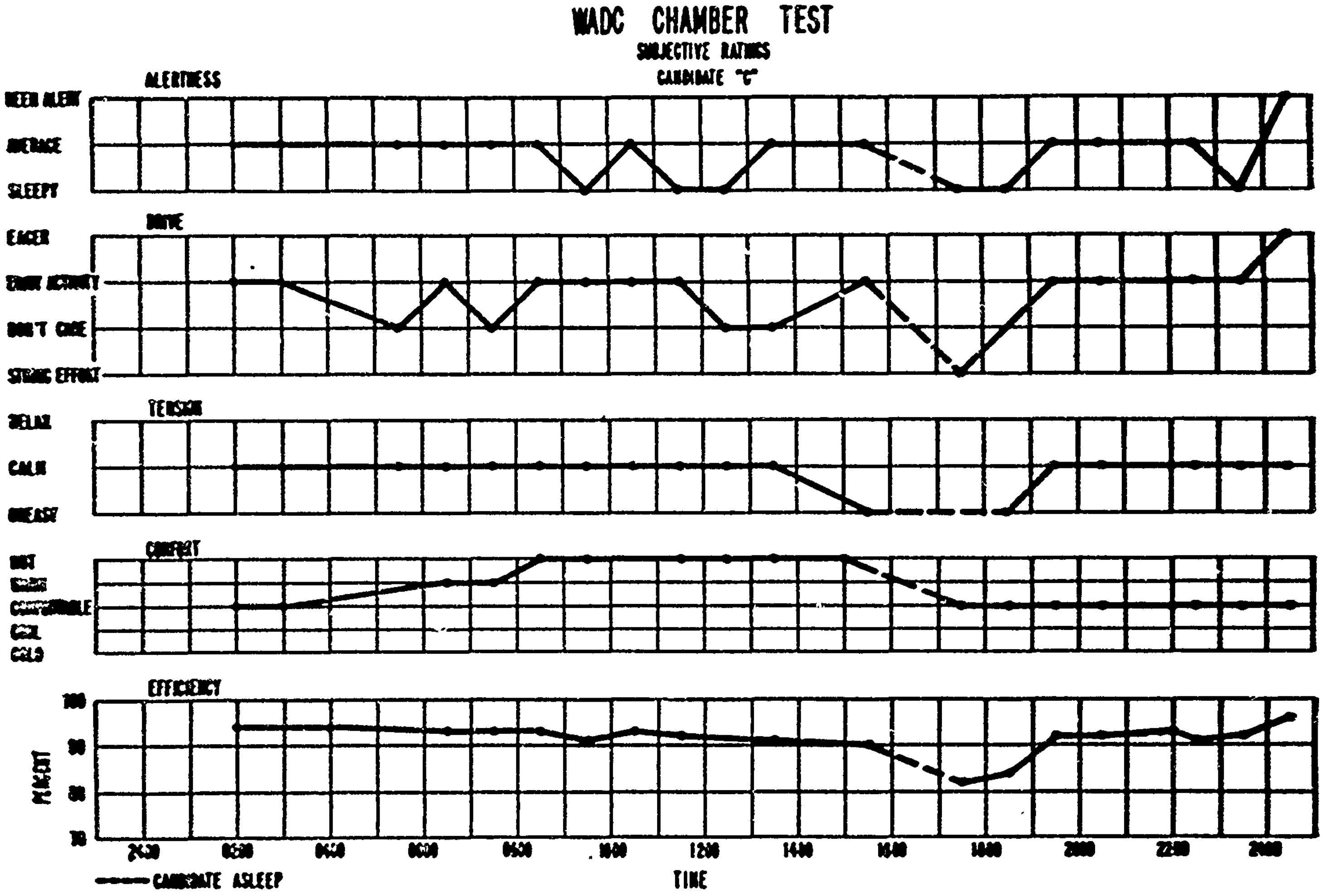


Figure 43. Subjective Operator Ratings During WADC Chamber Test (Subject C)

The time of this chamber run was directly comparable to an actual balloon flight. The candidate was dressed in his pressure suit and in the capsule by 2243 hours. Difficulties with the oxygen hose connection to the X-90 kit unexpectedly breaking, and the failure of the Strobe light of the subject camera to function properly delayed the procedures until it was 0015 when he was sealed in the capsule. Pressure-ascent began at 0635.

At 0430, two hours before the beginning of ascent, the following conversation was recorded between the monitor and the candidate:

INT: Okay, Mac, how do you feel about the whole thing about now?

CAN: Real great now. Say, I'm going to figure out when is the best time to sleep here. I'm not as sleepy as I could be, but I think I'll take an hour here. Can you get two hours before the test starts?

INT: I think you probably have about two hours, now, before the test starts.

Shortly after the 1100 pilot report (five hours after ascent), the candidate volunteered:

"Roger, I am not sleepy now, but if there is nothing to do and if you can't find anything to do I'm going to try to take a nap. I'd like to have something to do, if there is anything."

Shortly after noon, the following conversation was recorded with the psychiatrist monitor:

INT: How are you doing, old man? What do you know? Just blew in from Virginia last night, but the monitor said he had things well under control so we've let him control them. I hear though, that you are really the man who's got them under control. Oh, yeah, says you're sharp as a tack. That's debatable, I guess. How do you feel?

CAN: About like a tack.

INT: You mean you're sharp as one, or sitting on one?

CAN: Sharp as one.

INT: I'm glad to hear things are going well. We'll see you later.

CAN: Roger.

Shortly after this, the candidate volunteered the following request:

"Say, how about getting out that list on the spot photometer. Let's go through a trial run, even though it won't work. Let's try to start familiarizing myself with it, the dials and their function. How do you use it? What do you do? Is it hard to get down? Or hard to put back up? What are the knobs for?"

This is typical of the scope and depth of the curiosity of this candidate concerning the apparatus and the experiments to be conducted on the flight. The Project Physiologist, Captain Eli Beeding, normally reviewed emergency procedures with the candidates during the chamber run. The question of the critical timing of releasing the capsule from the balloon upon landing was mentioned several times and the importance of knowing the terrain altitude to assist in this function were reiterated in several different conversations. The doubts and concerns expressed at this time were well learned, as demonstrated later during the pilot's descent on the MANHIGH III flight.

At approximately 1515 (nine hours after ascent, the following conversation with the psychiatrist monitor was recorded:

INT: How are you doing, Okay?

CAN: Yeah, if you can be comfortable in a mummy box.

INT: I understand you had a little trouble urinating.

CAN: No trouble after I got the bottle and the machine up to do it with.

INT: That was quite exhausting, wasn't it?

CAN: It needn't have been.

Int: But you're feeling okay now and quite comfortable?

CAN: My inexperience in this capsule would have made quite a difference. But it was more exhausting by far than I expected.

INT: I see. Everything comfortable for you though?

CAN: Yeah, rather than say exhausting, let's put it this way, the position, plus everything else, the position you have to hold plus all the other operations I had to go through to get ready to do this, were by far very straining and strenuous, you know. As if you were straining to hold up a big load or something.

INT: I see. Well, your pulse rate's down now to about normal and everything reads okay so I assume that everything's very comfortable for you.

CAN: Roger.

At 2100 hours (15 hours after ascent), the following conversation was recorded with the monitor:

INT: I might tell you, Mac, that in the event that your power gets low in there, we will be able to feed some to you so you don't have to worry about an aborted run because of it.

CAN: Uh, I'm not worrying about anything, old buddy.

INT: Real fine. That's the kind of characteristics we like. Mac, have you slept any since way early this morning?

CAN: Negative.

INT: Real good. How do you stay so super?

CAN: Training, man.

INT: That's fine. What are you doing, Mac?

CAN: Checking out this light.

INT: What light?

CAN: That one.

INT: Oh. Okay, now I know what one you're working with. I'm getting the whine from the motor in the headset here and I couldn't figure out what was happening.

This illustrates the constant pressure of spontaneous activity expressed by this candidate throughout the run and his

irrepressible interest to know and to experience how everything works and to understand its operation completely.

Since this candidate was doing so well and the emergency suit pressurization systems had never been tested in the capsule under chamber flight conditions, it was decided to have a decompression test during descent. The chamber was leveled off at 65,000 feet, at which point the capsule was vented through the manual decompression valve to the chamber, reducing its internal pressure to the 65,000 foot level of the main chamber requiring that the partial-pressure suit inflate. The chamber was then dropped down to 40,000 feet, at which level the candidate could safely breathe the nearly 100 percent oxygen atmosphere within the capsule, if necessary. This experiment was conducted without mishap despite the profound level of fatigue of both operators and candidate.

During this decompression test, the candidate's pulse rose to 160 beats per minute which was a source of considerable concern to the monitoring personnel at the time. It had reached only 140 on the MC-1 partial-pressure suit, which indicates that the higher value of 160 had a primarily psychic origin since the MC-3A suit is a much better garment physiologically.

Unfortunately, the transcription of the debriefing recording is not available for this report.

The extremely labile pulse rate of this candidate was a source of some concern at times during the run, as it had been during his physiological stress tests. As shown in Figure 44, it ranged from 51 beats per minute to 115. Unfortunately, the skin resistance telemetry circuit was inoperative during this run. It is interesting to note that this candidate's foot surface temperature dropped shortly after the beginning of the run and then gradually climbed to approach that of his internal temperature. The variation in internal temperature during the early part of the run is doubtless attributable to instrumental error, since the candidate was experiencing serious difficulty zeroing the bridge circuit which measured the resistance of the temperature sensing thermistors. His respiration was more labile than that of the other subjects and the capsule temperature, while nearly identical to that of the previous run, was interpreted by this candidate as being warm during most of the flight.

The subject efficiency ratings illustrated in Figure 45, again ranged between 80 and 100 percent on a 0 to 100 percent scale. Obviously, much more decrement occurred during a 24-hour grind such as this. As a result of this "optimistic" bias introduced by the candidates, the pilot, during the flight itself, was

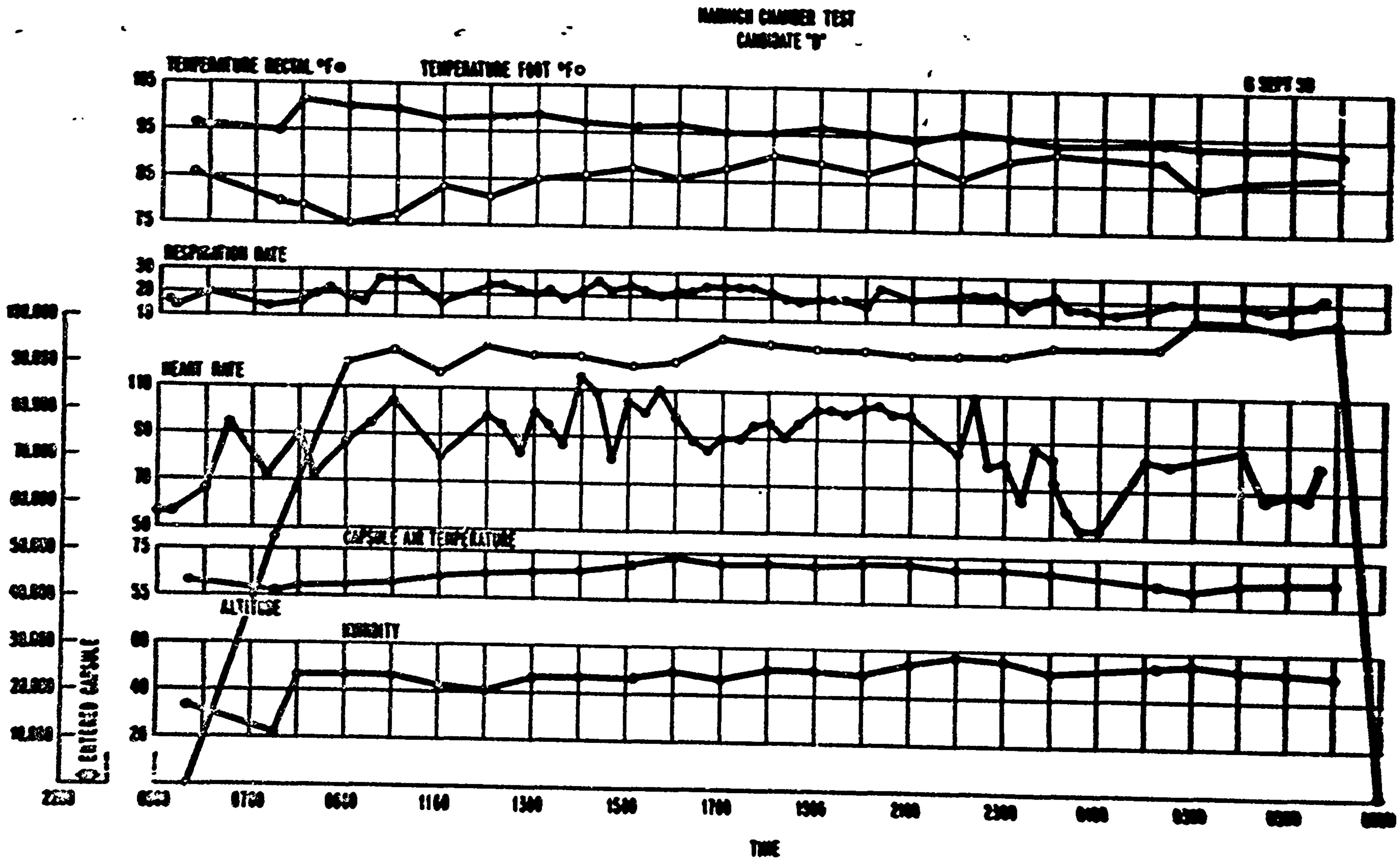


Figure 44. Physiological Data of WADC Chamber Test (Subject D)

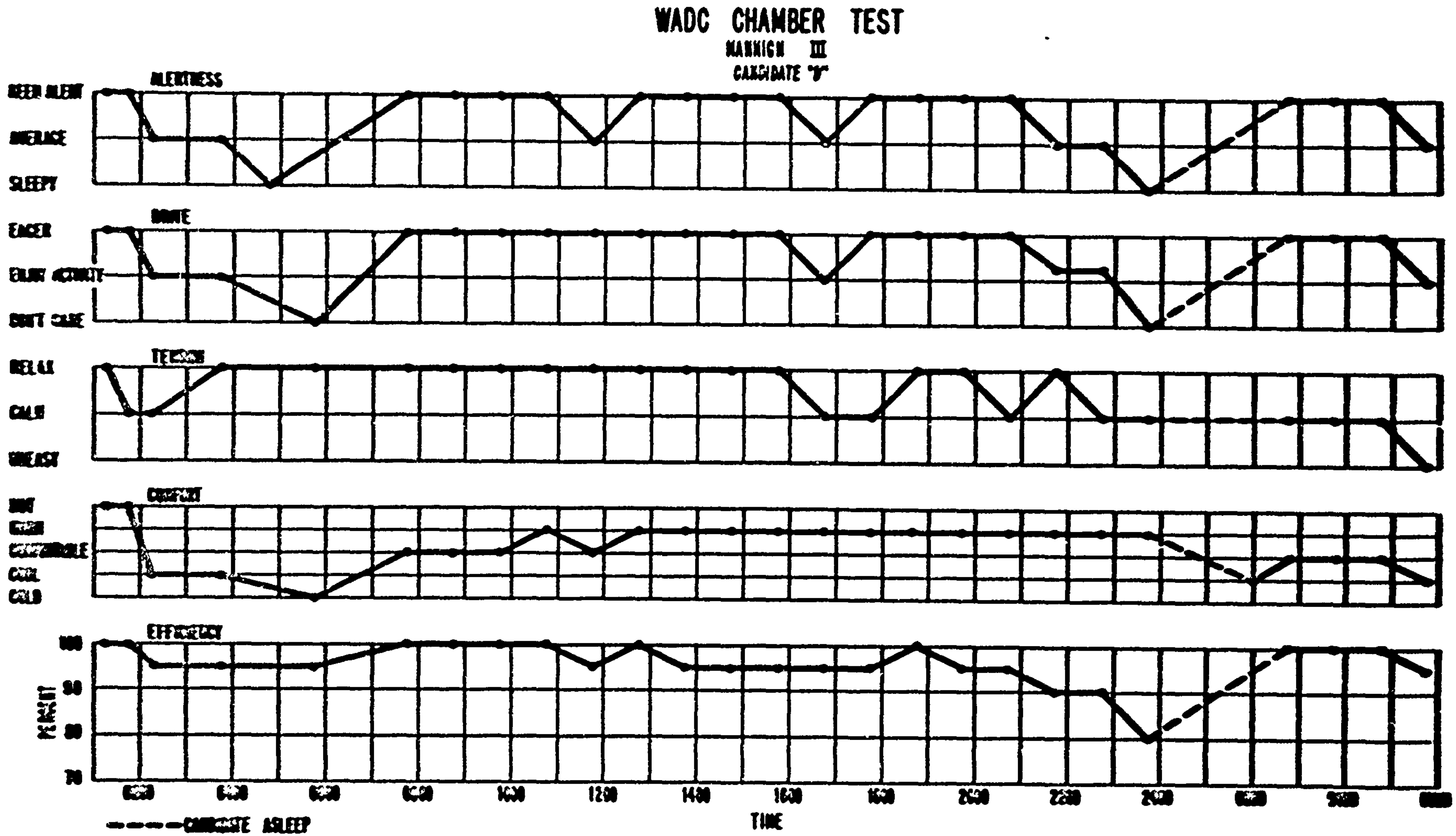


Figure 45. Subjective Operator Ratings During WADC Chamber Test (Subject D)

requested to change the center point from 90 percent efficiency, which had been par for the course to date, to 50 percent. This should provide a wider range permitting a more sensitive indicator of subjective feeling.

e. Candidate B.

Candidate B had donned his partial-pressure suit approximately three hours before the capsule was sealed. He prebreathed pure oxygen approximately 1-3/4 hours in his helmet with no apparent difficulties. He was sealed in the capsule at 1400 hours. So far as capsule performance was concerned, the chamber run was essentially uneventful. By approximately 0300 hours of the following morning, he began to indicate that it would be desirable to terminate the flight because of extreme discomfort caused by the wiring harness for the physiological instrumentation. This was essentially the same harness worn with moderate discomfort by other candidates. At 0500 he insisted upon termination of the flight, 15 hours after being sealed in the capsule.

When carefully examined two hours after removal from the capsule, moderate irritation was observed but no evidence of cutaneous injury.

8. Capsule Indoctrination

After Candidates C and D had completed the WADC simulated flight pressure chamber runs, they returned to Minneapolis where they still had the capsule indoctrination to complete and several Skycar flights to accomplish. Since the Skycar flights could be made only under favorable weather conditions (relatively clear skies and low surface winds), the time spent waiting for favorable weather was spent being checked out in the capsule and becoming completely familiar with the position of all controls, their operation and the mechanism they control. At the same time, the pilots were encouraged to practice using the scientific instruments for conducting the various experiments included on the flight.

9. Supplementary Examinations

A part of the preflight schedule of each pilot included examination by Dr. David V. L. Brown of Chicago, Illinois. Dr. Brown conducted a thorough ophthamalogical examination, including a meticulous slit lamp examination of both eyes in order to have as thorough a knowledge as possible of the internal eye

structures and visual acuity of the candidate before flight. Corresponding examinations accomplished at regular intervals postflight were scheduled to detect any changes attributable to exposure to heavy primary cosmic rays.

In addition to the above examination, Candidates C, D, and E were examined by Dr. Herman B. Chase of Brown University for evidence of grey hair on the head, forearms, and chest. This examination served as a control for postflight examinations to detect any evidence to greying caused by exposure to heavy primary cosmic rays. This was especially important when the flight was initially expected to take place from a northern latitude where the pilot would be exposed to heavy primary thindowns during flight.

CHAPTER IV

FLIGHT SURGEON'S REPORT*

A. THE PANEL OF EXPERTS

After the MANHIGH II flight, it was common for me to be speaking to an expert in some scientific discipline in which observations were attempted during the flight and to have the scientist ask a question about whether I noticed so and so, or whether such and such was the case. Although a major effort had been made to anticipate as many questions of this type as possible, naturally, many of them were missed. In addition, the observations that were made frequently generated new questions or emphasized aspects that had not been anticipated before the flight. It is obviously not practical to take along a group of scientists to stratosphere altitude at the present stage of development of balloon technology. However, it did appear reasonable and feasible to provide a selected panel of experts with an opportunity to converse with the pilot during the flight, letting him be their eyes, so to speak, so that they could ask their questions while the balloon pilot is actually making the observations. In this way it was expected that the number and quality of observations made on a given topic would be equal to that attainable only after two or three consecutive flights, using ordinary flight-debriefing - repeat flight techniques.

In principle, this technique worked very satisfactorily on the MANHIGH III flight. Unfortunately, the scientific observations made by the pilot had to be discontinued shortly after the observation program had started because of unexpected critical hyperthermia.

The Panel of Experts included:

1. Psychiatric Consultant - Captain George Ruff, Stress and Fatigue Section, Aeromedical Laboratory, WADC. Dr. Ruff planned to observe the pilot's performance through the manner and content of his answers to other panel members' interrogation, as well as through specific interviews similar to those held during the WADC chamber runs. His presence on the panel, during the flight, turned out to be most fortunate.

* By Lt Colonel D. G. Simons

2. Aviation Physiologist - Captain R. L. Beeding, as Project Physiologist at the time of the MANHIGH III flight, was responsible for recording physiological data, including supervision of the telemetry data being monitored by contractor technicians and data transmitted verbally by the pilot. Because of his experience in maintaining the monitor logs and pilot report data sheets during the chamber runs, he was given primary responsibility for this function during flight. In addition, he was responsible for ensuring the collection of the corticosteroid stress experiment samples previously described in the MANHIGH II Report* for Captain Archibald.

3. Flight Surgeon - Lt Colonel David G. Simons. As Project Officer, and having had the experience of making the MANHIGH II flight, the author was designated Flight Surgeon for the flight. In addition, I was responsible for the schedule of observations and arrangements for the Panel of Experts. Because of my previous flight experience and research interests, I was the panel member responsible for the visibility experiments included on the flight and for the eye and hair greying cosmic radiation experiments previously mentioned.

4. Sky Luminance and Radiance Experiment - Dr. S. Q. Duntley of Scripps Oceanographic Institution was responsible for this experiment through the auspices of Dr. Vincent Stakudis, of the Air Force Cambridge Research Center. Mr. Boileau represented Dr. Duntley during the flight. They were primarily interested in the data obtained from the spectrum spot photometer.

5. Stability Experiment - Mr. George Nielson represented Dr. Allen Hynek of the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts, in conducting telescopic monocular and night star track photographic studies of the frequency, direction, and magnitude of capsule oscillations. The last two experiments produced scanty data because of the short period available at altitude during the flight in which to make observations.

6. Meteorologist - Mr. Bernard Gildenberg, who, in addition to being primarily responsible for meteorological data obtained by the pilot during the flight, offered a number of suggestions in the astronomical area and served as official project meteorologist forecasting high altitude winds.

* MANHIGH II, USAF Manned Balloon Flight into the Stratosphere, AFMDC-TR-59-28, June 1959

7. Astronomer - Mr. George Nielson represented Dr. De-Vaucouleurs of the Harvard Observatory as Panel Astronomer *in absentia*.

8. Cosmic radiation monitoring experiments were conducted by Dr. Herman Yagoda, now of the Air Force Cambridge Research Center. He also conducted a micrometeorite experiment recently reported*.

9. Experiments conducted without panel participation - (a) The Eastman Kodak Company supplied equipment under contract for a classified Air Force experiment, (b) Dr. Dyme and Beatrice Finkelstein of the Nutrition Section of the Aeromedical Laboratory, WADC, provided the food and diet recommendations during the chamber runs and the high altitude flight and (c) Major Carl Ferriby, Reconnaissance Laboratory, WADC, expended a great deal of effort in preparing a camera package which included a group of cameras that took pictures with various types of film and filters, a strip camera which recorded pictures from horizon to horizon, and a Scaterrometer. Unfortunately, the complications introduced by including this large, heavy, but valuable package were more than could be handled (Fig. 46). As the time for flight drew near it looked very much as if it had become a question of fly without this experiment or don't fly at all. Unexpected difficulties, such as change of launch site dictated this decision. The primary purpose of this experiment was to provide data which could be correlated with the pilot's visibility observations after the flight, so that there would be both objective and subjective data for comparison.

In order to permit this group of Panel Experts to monitor the balloon flight situation, a bus was equipped with a speaker so that when the bus and communications trailer were parked, the speaker could be plugged in and all panel members could listen to conversations between the ground and the capsule. The communication trailer used by the command group had one microphone available for the use of whichever panel member's experiment was being conducted at that time.

In the event that the balloon traveled too fast at altitude to permit adequate monitoring with the mobile ground equipment, a C-47 was equipped to carry the command group and the Panel of Experts. It had an eight-place table with two microphones and eight sets of earphones. This provided a place for each of the command group and a place for whichever panel member was "on deck".

* Yagoda, Herman, "Observations on Nickel-Bearing Cosmic Dust Collected in the Stratosphere", AFCRC-TN-59-200, March 1959.

Figure 46. MANHIGH Capsule with the "Ferriby" Package Attached

Scheduling of the pilot's time to make optimum use of the flight opportunity was a major problem. While waiting for satisfactory flight weather, Mr. George Nielson very kindly assisted in the preparation of the following schedule which was used during the flight:

PRELAUNCH

WWV Time Check

Wind shear and cold temperature altitudes

Desired ascent rate

ASCENT

	0 - 5 K	K-100 movies
	5 - 10 K	Hasselblad pix out and down
	10 K	Antenna release
	10 - 20 K	Establish ascent rate
	20 K	Check photo panel camera
	20 - 25 K	Hasselblad pix out and down
	25 - 40 K	Wind 30 sheer alert - check action of ducts
	40 - 45 K	K-100 movies
	45 - 65 K	Establish capsule atmosphere - pilot report
	65 - 68 K	Hasselblad pix out and down
	68 - 78 K	Air temperature - 3 per min - check ducts
	78 - 82 K	Pilot report
	82 - 90 K	Air temperature - 1 per min
Yagoda	90 K	Pull first film tab
	90 K	Check ducts and poly strips
	90 - 92 K	Air temperature - 1 per min
	92 K	Check ducts and poly strips
	92 - 94 K	Air temperature - 1 per min
	94 K	Check ducts and poly strips
	94 - 96 K	Hasselblad pix out and down

	96	K	Check ducts and poly strips
	96 - C	K	Air temperature - 1 per min
	C	K	Check ducts and poly strips
	C	K	Pilot report
	C	K	K-100 movies out and down

CEILING ALTITUDE

Time - 0800

	45	Check marker beacon off
Nielson	45 - 48 C/5	Stabilization of ascent rotation
Ruff	48 - 53 C/8	Dr. Ruff
	53	Pull 2nd film tab
Nielson	53 - 55 C/8	Stabilization of ascent rotation (K-100)
	55	Check thermistor
	55 - 58 C/10	Check balloon action; folds, ducts, etc.
	58	Check photo panel camera
	58 - 60	Hasselblad pix out and down

Time - 0900

	00 - 08	Pilot report
Nielson	08 - 10	Stabilization of ascent rotation (K-100)
	10 - 12	Urination
	12 - 15	K-100 movies down and out
Nielson	15 - 17	Stabilization of ascent rotation (K-100)
	17 - 23	Check balloon action
	23 - 45	Quadrent pictures visibility and stabilization
	45 - 60	

Time - 1000

	00 - 08	Pilot report
	08 - 10	

	10 - 25	Subjective remarks / window frost
	25	Check photo panel camera
	25 - 50	
Yagoda	50	Pull 3rd film tab
	50 - 60	

Time - 1100

	00 - 08	Pilot report
Nielson	08 - 30	Monocular stability check
	30 - 45	Quadrent pix - visibility
	45 - 55	Silence and introspection
	55 - 60	Light level in and out of capsule

Time - 1200

	00 - 08	Pilot report
	08 - 10	
Boileau	10 - 25	Spot photometer
	25	Check photo panel camera
	25 - 30	
Yagoda	30	Pull 3rd film tab
	30 - 60	Eastman experiment K-100

Time - 1300

	00 - 08	Pilot report
Boileau	08 - 23	Spot photometer
	23 - 28	Subjective remarks / window frost
	28 - 43	Quadrent pix - visibility
Nielson	43 - 60	Monocular stability check

Time - 1400

	00 - 08	Pilot report
	08 - 10	
Boileau	10 - 25	Spot photometer
	25	Check photo panel camera

Ruff	25 - 35	Dr. Ruff
	35 - 50	
Yagoda	50	Pull 4th film tab
	50 - 60	

Time - 1500

	00 - 08	Pilot report
	08 - 10	
Boileau	10 - 25	Spot photometer
	25 - 30	Eye patch on
	30 - 45	Quadrent pix - visibility
Yagoda	45 - 50	Check retinal flashes
Nielson	50 - 60	Daytime star color and scintillations

Time - 1600

	00 - 08	Pilot report
	08	Balloon duct check
	08 - 10	Air temperature
Boileau	10 - 25	Spot photometer
	25 - 35	Subjective remarks / window frost
	35	Check photo panel camera
	35 - 38	Air temperature
	38	Balloon duct check
	38 - 40	
Yagoda	40	Pull 5th film tab
	40 - 55	Quadrent pix - visibility (-UV Filter)
	55 - 60	Light level in and out of capsule

Time - 1700

	00	Thermistor <u>on</u>
	00 - 08	Pilot report
	08	Check air ducts
	08	Check balloon ducts

	08 - 10	Air temperature
Boileau	10 - 25	Spot photometer
	25 - 30	Silence and introspection
	30	Check balloon ducts
	30 - 32	Air temperature
Boileau	32 - 60	Eastman experiment K-100

Time - 1800

Nielson	00 - 02	Hasselblad sunset pix
	02 - 08	Pilot report
	08	Check marker beacon <u>on</u>
	08	Check air duct
	08 - 10	Air temperature
	10	Check balloon ducts
Nielson	10 - 13	Hasselblad sunset pix
Nielson	13 - 17	Sunset timing
	17 - 22	
	22 - 25	Approximate time - green flash movies
Boileau	25 - 29	Spot photometer arch observations
	29	Check balloon ducts
	30 - 32	Air temperature
Boileau	32 - 36	Spot photometer arch observations
	36	Check photo panel camera
	36 - 42	
Boileau	42 - 46	Spot photometer arch observations
Yagoda	46	Pull 6th film tab
	46 - 60	Quadrent pix - visibility (-UV Filter)

Time - 1900

	00 - 08	Pilot report
	08	Check air duct
	08	Check balloon ducts
	08 - 10	Air temperature

	10	Check thermistor
	10 - 25	
	25 - 27	Air temperature
	27	Check balloon ducts
	27 - 35	Subjective remarks ≠ window frost
Nielson	35 - 45	Approximate time Jupiter sets
	45 - 47	Air temperature
	47 - 50	
	50 - 55	Zodiacal light
	55 - 60	

Time - 2000

	00 - 08	Pilot report
	08	Check air duct
	08	Check balloon duct
	08 - 10	Air temperature
Nielson	10 - 20	Approximate time - Mars rising
	25 - 30	Air glow experiment
	30	Check balloon ducts
	30 - 32	Air temperature
	32	Check photo panel camera
	32 - 38	
Nielson	38 - 39	Star track camera goes on
	39 - 42	Air temperature
	42 - 45	Zodiacal light
Ruff	45 - 55	Dr. Ruff
	55	Pull 7th film tab
	55 - 60	

Time - 2100

	00 - 08	Pilot report
Yagoda	08 - 25	Scintillation experiment ≠ retinal flashes

	25 - 27	Check beacon visibility
	27	Check thermistor
	27 - 30	Urination
Nielson	30 - 32	Star track camera calibration (Hor.)
	32 - 35	Zodiacal light
	36 - 60	

Time - 2200

	00 - 08	Pilot report
Yagoda	08 - 12	Lucite block
	12 - 20	
	20 - 30	Subjective remarks / window frost
	30	Check photo panel camera
Gildenberg	30 - 35	Clouds
	35 - 40	Air glow experiment
	40	Pull 8th film tab
	40 - 60	

Time - 2300

	00 - 08	Pilot report
	08 - 18	Approximate Saturn setting
	18	Check thermistor waver
	18 - 30	Monocular stability check
	30 - 32	Star track camera calibration (Ver.)
	32 - 37	Silence and introspection
	37 - 40	Moon rise pix and timing
Nielson	40 - 60	Visual scintillation check
	60	Check VHF receiver off

Time - 2400

	00 - 60	Sleep

Time - 0100

	00	Pull 9th film tab
	00 - 08	Pilot report

	08	Check photo panel camera
	08 - 10	Moon rose picture
	10 - 15	Moon - spot photometer
	15 - 25	Zodiacal light
Gildenberg	25 - 27	Clouds
	27 - 30	Air glow experiment
	30 - 40	Subjective remarks / window frost
	40 - 60	

Time - 0200

	00 - 08	Pilot report
	08 - 10	
Nielson	10 - 25	Monocular stability check
	25 - 27	Star track camera calibration (Hor.)
	27	Check photo panel camera
	27 - 30	Zodiacal light
Nielson	30 - 50	Hasselblad F 2.8, 1 sec star pix
	50	Pull 10th film tab
Ruff	50 - 60	Dr. Ruff

Time - 0300

	00 - 60	Sleep

B. FLIGHT PREPARATIONS

To appreciate the psychiological setting and the emotional context in which Lt McClure performed the MANHIGH III flight, one must remember that the MANHIGH project was under official orders to terminate as soon as possible through the final weeks of the program. The competition between the pilot and standby pilot in the sense of "who will be the one to go" was intensely keen. It was mid-September, both candidates had completed all requirements through the WADC chamber test, needing only the required Skycar time for a CAA license when Mr. Gildenberg, the Project Meteorologist, set the end of September as a tentative cutoff date for a flight from Crosby, Minnesota, because of the reversal of high altitude winds at that time of the year.

At this point, Candidate D, Lt McClure, became the No. 1 pilot and Candidate C the standby pilot as previously explained. Day after day was spent rehearsing capsule procedures, awaiting sufficiently clear weather for a Skycar flight. Finally, the late Mr. Lee Lewis, the Instructor Pilot, started moving westward with Lt McClure and the launch crew in the hope of finding a break in the weather.

Finally, on 25 September, Mr. Lewis and Lt McClure were able to get the Skycar off from Bismarck, North Dakota, completing that flight the same day. They returned quickly to Minneapolis to take advantage of another break in the weather to complete the second Skycar flight on 27 September. Lt McClure completed his CAA license requirements by making a one-hour solo flight the following morning, Sunday, 28 September. Grateful for the good weather that permitted the quick completion of the Skycar requirements, the same question weighed heavy in Lt McClure's heart, as in every project member's, "Would the surface weather clear for a launch from the Crosby Iron Mine before Mr. Gildenberg's deadline?"

On 29 September the latest weather reports from Mr. Gildenberg made it clear that the operations plan must be modified to account for an eastward trajectory of the capsule at high altitude. The winds had changed. By afternoon of 29 September, the prediction for two days hence looked quite hopeful. Everyone moved to Crosby the following day prepared for an early morning 1 October launch.

At 1800 on the evening before the scheduled launch, Lt McClure got up to eat and dress in the pressure suit. At the same time, review of the latest RAOBS (high altitude wind weather reports) looked quite discouraging. The launch weather looked perfect but the flight would end 100 to 200 miles south of James Bay, in the Hudson Bay area. Even with a perfect flight and perfect weather, this would be a nearly impossible area in which to recover the pilot after the flight. The weather in that area was forecast to be stormy. Might the upper wind picture change in the next several hours? Might it be possible to reduce the flight time and land in a reasonable area for recovery? These and many other possibilities were thoroughly explored. By 2230 it was clear that a flight from Crosby the next morning was out of the question.

The following day a complete review by Colonel Hessberg of the pros and cons of the three possible launch sites - Crosby, Minnesota, Rapid City, South Dakota (the Stratobowl), and Holloman Air Force Base in New Mexico were thoroughly discussed. Mr. Gildenberg assured us that there was a negligible chance that a

period of satisfactory high altitude winds would occur for a Crosby launch during October and would likely occur several times in November. However, time limitations on the project precluded this possibility. The high altitude winds were already too strong to permit a satisfactory recovery from the Stratobowl. Colonel Nessberg decided that Holloman Air Force Base was the only reasonable choice.

This meant the loss of the cosmic radiation experiment and required that the recovery be the responsibility of the AFMDC Balloon Branch. This group, although well trained and acquainted with balloon tracking and recovery techniques, had never integrated efforts with this contractor group or been responsible for a high altitude manned flight. The remarkably fine teamwork exhibited by all concerned in successfully conducting the flight from Holloman is a commentary on their high level of competence and the spirit of complete cooperation among all concerned.

In two days, on 3 October, the Air Force C-47 left Minnesota loaded with all necessary equipment, including the only two balloons manufactured to manned flight specifications.

On Sunday, 5 October, all key contractor and project personnel met at AFMDC for a briefing of the new operations plan. The next morning, Monday, would not have satisfactory ground winds for launch. Tuesday morning looked hopeful. Lt McClure returned to the "night shift" so that he would be arising at 1800, and would be entering the capsule with as much rest as possible. This was required by a dawn launch which was dictated by balloon flight considerations when conducting a 24-hour flight.

On the afternoon of 6 October, a command decision was required. The launch weather for the next morning looked far from certain, but hopeful. The tropopause temperature was cold but tolerable and the high altitude winds favorable. The decision was to go ahead and prepare for flight unless the situation deteriorated. At worst, the project would lose one of the two balloons by going ahead. If we missed the only flight opportunity for the next few weeks, it could well mean no flight at all.

Lt McClure was given his final physical check and was sealed in the capsule. The capsule checked out without difficulty and was brought to the launch site on schedule. At 0625, the rays of the rising sun illuminated the contractor personnel refilling the dry ice cap on the capsule. Balloon inflation was ready to begin, committing the balloon. Lt McClure joked confidently of the observations to be made later that day at 100,000 feet. Barely 10 minutes before inflation would have been completed and the

flight launched, a gust of wind caught the balloon and destroyed it. Fortunately, the weather predicted for the following morning was more favorable.

Lt McClure was given seconal and put to bed and preparations begun for another attempt to launch the flight the next morning.

His preflight physical this time revealed a slight cold but no temperature. The feeling common among the project personnel that this was a last chance try was betrayed by the pilot in a slight exaggeration of his characteristically unquenchable enthusiasm.

The pressure suit checked out without difficulty on the console. Lt McClure was sealed in the capsule and the procedure started for establishing the capsule atmosphere. Captain Beeding asked for a reading of Item 7. As Lt McClure turned to comply with this request, an accident occurred which Lt McClure had imagined and dreaded, but to which he had been unable to think of a satisfactory answer. The chest pack parachute included for pilot escape from the capsule in the event that the operation of the emergency capsule parachute was unsatisfactory or unusable, was one of a kind. It was rigged especially for use in this capsule and there was no replacement at AFMDC.

It is possible that he had accidently pulled the rip-cord. The parachute lay in his lap.

Although not trained as a parachute packer, Lt McClure, several months before, had observed carefully the packing procedure and satisfied himself at that time that he knew how each step was accomplished and why. He immediately knew that to report the accident and abort the flight would delay it for at least one day, doubtless beyond the good weather we were fortunately experiencing. To try to repack it would require superhuman effort.

He decided the only thing he could do was try. Slowly and with meticulous care, he carefully repositioned the silk in his lap fold by fold, having to interrupt his labors frequently to answer requests for readings and to hide his task from prying eyes outside the capsule.

The capsule had checked out perfectly, its atmosphere established. It was time to transfer the capsule from the assembly building to the launch site. Although the parachute was still not encased in its pack, it was refolded and ready for final assembly. Carefully nursing it during the trip, he anxiously resumed his desperate labor, straining with his last ounce of

strength to force the stubborn material into the impossibly small space of the parachute pack. With strength derived from pure desperation, he managed to finish the job, each landyard and pin in its proper position. Checking and re-checking his work, he was relieved and confident that it was done well. He was betting his life on it. In addition, he had a deep sense of responsibility toward those in charge of the flight. He fully reported the incident on the tape recorder so that should any unexpected complication arise during the flight, this facet of it would be known.

A scant 20 minutes before launch time, he could relax for the first time in hours and enjoy the preflight preparations. The balloon was again straining high above him, nearly inflated. The wind was calm and all looked well.

Apparently because Lt McClure was reporting a cooler, more comfortable temperature this morning than he had the day before, the contractor engineers responsible for the capsule decided not to repack the dry ice cap but to send it aloft without additional cooling. On both the previous MANHIGH flights, this cap had been repacked with dry ice within an hour before launch.

C. THE FLIGHT

At 0651, on the morning of 8 October 1958, the flight cleared the ground. The pilot was on his way.

The ascent went essentially as planned. A slightly high ascent rate required Lt McClure to valve off excess free lift during the first half hour. The balloon system responded well and all turned to their prescribed tasks of observing and recording data.

The tape recorder of all voice communications between the command communications trailer and the capsule was working. The telemetry write-out had little interference and all channels seemed to be functioning properly. Only the panel temperatures read by the pilot were inordinately high, 118°F. It was soon established that this was caused by the fact that the sensing element was accidently left out of reach on top of the CO_2 and water absorbing air regeneration unit which used a highly exothermic chemical reaction. This reading was readily explainable, but essentially meaningless.

The pilot reached ceiling altitude of almost 100,000 feet at 1000, not 0800 hours as planned on the pilot observation

schedule. We corrected by starting his activities at the 1000 point on the schedule, eliminating the observations planned for the first two hours. We started by having him begin with the subject's remarks to the on-board tape recorder. It was necessary for him to turn the cartridge in the recorder at this time, having filled the first side with the story of the parachute difficulties. It later turned out that in the process, a battery lead broke so that the tape recorder failed to function from this point on in the flight.

All was going smoothly so we asked him to have a snack to eat during his silence and introspection between 1140 and 1150 while we evaluated the trajectory situation. He had now been at ceiling altitude long enough for us to anticipate his speed and direction of travel. By noon, it was apparent that he was moving to the northwest at a much more rapid rate than had been anticipated. It would be necessary to leave the communications trailer and fly in the C-47 to a rendezvous point to the northwest. After the 1200 pilot report, which included a tape recorded interview for a mewsman, and while Lt McClure started his 1215 spot photometer readings, the command group and Panel of Experts transferred to the C-47.

The command group was composed of six people; Lt Colonel Rufus R. Hessberg, Chief of the Aeromedical Field Laboratory was officer in charge of the total operation. The author, as Project Officer, was the Project Flight Surgeon and Director of the Panel of Experts. Captain Beeding was Project Physiologist. Mrs. V. H. Winzen, acting President of the Winzen Research, Inc., directed the contractor group which included Mr. Lee Lewis who was in charge of balloon launch and balloon flight operations, and Mr. Donald Foster, the contractor's Project Engineer.

Lt McClure later observed that he had found the interview with the press at noon, surprisingly exhausting. He reported that the spot photometer observations he made next left him "really exhausted". At this point, neither he nor anyone else suspected the nature of his problem.

While he was completing the spot photometer readings, the C-47 had become airborne and the command group was again organized and in communication with him. Starting at 1245 hours, he was busy with efforts to follow the count-down of a missile which was scheduled to destroy its target at 80,000 feet, 20,000 feet below him. The prospect of capturing a downward looking view of this event captivated everyone's attention until the missile firing was cancelled 15 minutes later (1300).

At that time, a review of the situation revealed that Lt McClure's voice showed signs of deteriorated performance and he stated that he felt warm. His telemetered pulse rate had gradually climbed from a normal 80 beats per minute recorded during ascent to a high 140 beats per minute. Knowing his reputation for a labile pulse, this in itself was not considered cause for alarm. However, his reported internal temperature of 101°, if reliable, was a serious omen. The telemetered capsule temperature was 76°F, so this made no sense. In any case, it did make sense to have him drink water since Captain Beeding discovered that in all of the excitement, Lt McClure had failed to take in any liquid since 0200 - over 13 hours before.

At this point, the tube to his drinking water supply would not function properly so he was able to get only a tantalizing few drops of water at a time. After a tense ten minutes, by 1315, he discovered a method to make it work satisfactorily and began to force his liquid intake.

Now, he was requested to resolve the contradictions among the extremely high panel temperature, the normal telemetered cabin temperature, and his elevated internal temperature and pulse rate by reading the cabin air temperature from the mercury thermometer on the dry bulb side of the psychrometer used to calibrate the automatic but less reliable panel instrument.

Between communication difficulties and preoccupation with other matters, the reading was not obtained in the C-47 until 1350 hours. It was 96°F at head level and it was confirmed by the pilot as reliable and accurate because he had removed the cotton sock from the wet bulb side of the psychrometer and observed the same reading on the other independently calibrated mercury thermometer.

The 1330 report of his internal temperature had been 102.3°. Was this reliable? The check of the earlier transmitted reports showed normal readings until 1000 when a slow steady rise began. Knowing that the air temperature must have slowly climbed to 96°F, this made sense.

How serious was the situation? And what action, if any, would be necessary? From my MANHIGH II experience, I was able to point out that it had not been until 2200, several hours after sunset on the capsule, that the temperature in the capsule began to decrease. It had been several more hours until it became comfortable in the capsule. One of the consistent observations made by all candidates and previous pilots was that any environmental temperature in excess of 68°F, plus or minus just a few degrees, was

uncomfortably warm, and anything over 80°F was downright intolerable for an extended period of time. The inexorable upward march of his internal temperature confirmed that 96°F was well beyond a tolerable limit. He must start down immediately.

This decision was reached at about 1400 hours by Colonel Hessberg in conjunction with those responsible for the flight. It was now a question of how to tell Lt McClure he must valve down. By now, his internal temperature was 103.4°. This was already a serious fever and he had not begun to descend from altitude. When he was told that he had a serious temperature problem and would need to descend to cool off, he at first asked if he could not remain at altitude to perform the observations that he had come to make. He was told that the command group had decided it was necessary for him to come down to a lower altitude, at least to around 50,000 feet, where his capsule would be much cooler.

At this point, the lesson learned from MANHIGH I, and demonstrated by the near tragic game of who is fooling who, desperately played between Admiral Byrd and his base camp during his epic winter alone in Antarctica, proved extremely valuable. There had been a firm agreement on the MANHIGH II flight and I had personally briefed Lt McClure on the sacrosanct working principle that he was in charge of the flight as pilot, at all times without questions from the ground as long as things were under control. The ground command group would respect this and <u>demand</u> nothing contrary to his judgement unless the situation reached a point where it was an absolute emergency, life and death matter, and they felt they had sufficient information to make the decision inescapable regardless of what he thought. We would be scrupulously honest with him at all times, expecting the same in return. This was primarily to protect him in the event the situation had reached the point where his judgment could no longer be relied upon. This agreement had been reached to cover just such an emergency as this, and upon radio discussion with Colonel Hessberg, he respected it, and started to valve down at that time.

He was instructed to valve repeated small increments of the total valving time predicted and then await results. Again and again no results were apparent. The contractor's representative responsible for flight operations, was concerned that he had established too high a descent rate in the stratosphere, presenting a high velocity landing hazard when the descent rate doubled upon reaching the troposphere. By 1500, he had descended only a few thousand feet and still had not established a consistent and reliable descent rate. His internal temperature had reached

104.1°. Now, the pilot himself appreciated the urgent need for descent to an altitude where the capsule would be cooler. He was completely cooperative and, except for occasional pictures and comments to the tape recorder, he concentrated on relaxing to conserve his waning energy to meet the demanding responsibility of landing the flight.

At this point, there seemed but slim hope that the balloon would bring him safely to earth before his inexorably soaring internal temperature would render him unconscious.

By 1600 hours, the balloon had established a gratifying descent rate of approximately 500 feet per minute and was passing through 87,000 feet - still a long way up. Another hour and another degree rise in his internal temperature. One small bit of encouragement was the fact that his report of the internal capsule temperature using the mercury thermometer, had shown an increase of only one degree, 97°F. His heart rate (Fig. 47, however, was fast approaching 180 beats per minute, the limit of physiological compensation. This is the point of maximum response to stress at which physical performance tests are discontinued.

The command group faced a most difficult command decision. In the face of his steadily rising temperature and his already alarmingly high fever, no one dared predict how much longer he would remain conscious. Should he pass out, undoubtedly the only way of bringing him to earth rapidly enough to have a chance of saving his life would be to release the parachute and capsule from the balloon bringing him down on the emergency cargo chute. This necessarily involves a hard landing which in itself could inflict critical injury if he did not have his shoulder harness and safety belt securely fastened. On the other hand, to request that he strap himself tightly against the seat and the 2-clo thermal suit, would reduce the little ventilation he still had. This would aggravate his thermal problem and multiply his discomfort. The latter seemed the lesser of the two evils.

Colonel Hessberg, as Chief of the Aeromedical Field Laboratory, again exercised the command prerogative and instructed him to fasten his suit belt and shoulder harness. Lt McClure again respectfully pointed out the disadvantage to his situation, but when told that it was the command group's decision and that it was necessary, he complied without further question. Later, during the debriefing, he stated that he appreciated the reasoning behind our request and had by that time come to realize that he faced a desperate situation.

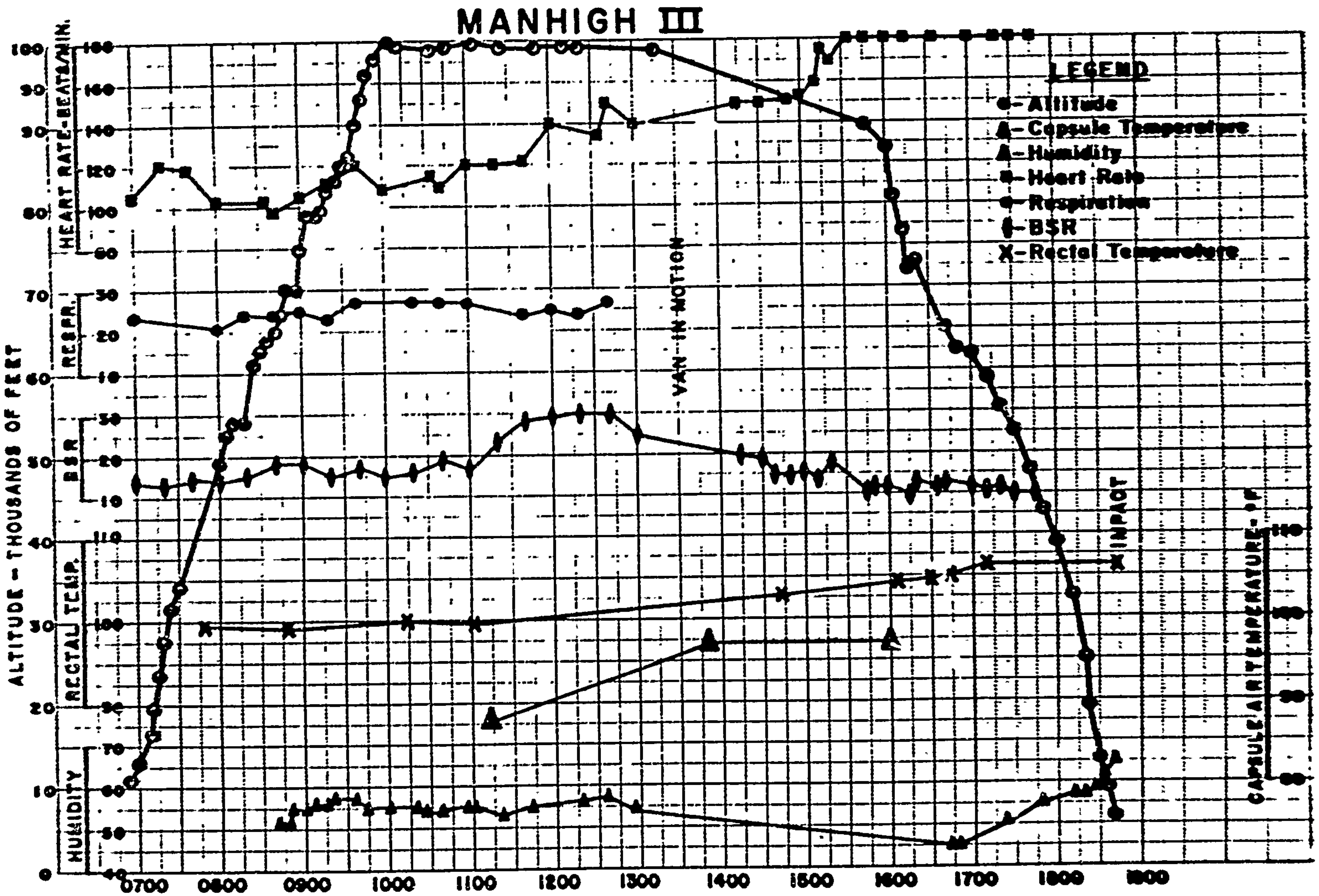


Figure 47. Physiological Data and Flight Altitude Obtained During the MANHIGH III Balloon Flight

Lt McClure and the command group were plagued by a further serious difficulty for the remainder of the flight. Communication between the C-47 and the capsule were permanently interrupted when Lt McClure dropped his spot photometer on the floor where it jammed the foot switch of the capsule transmitter. He could receive but not transmit. For the next two hours the command group had no way of being certain that Lt McClure was still conscious except for one isolated report that a ground station had contact with him around 1700. Should they initiate command separation and precipitate immediate descent of the capsule on the parachute, or should they wait, assuming that Lt McClure was still conscious and in command of the capsule but simply having communication troubles. The only hint they had that he was still in no worse condition than before was the telemetered transmission of a steady pulse rate of 180. The respiration sensor had ceased to function at 1245 and the internal body temperatures were reported by the pilot himself.

Shortly after sunset, as Lt McClure descended through 25,000 feet, the flashing night marker beacon came on, confirming that he was still conscious and in control.

A long 40 minutes later, the capsule landed in the dark within a few miles of the runway from which it had been launched nearly 12 hours before. A recovery helicopter landed beside it a few minutes later in time to see Lt McClure remove the upper hemisphere and crawl out under his own power.

The last setting of the temperature bridge was 108.3°F and Lt McClure remembered that the needle was off zero by an amount that represented an additional 0.2°. The final internal temperature reading at the time of landing was 108.5°F. It had continued to increase throughout descent, although the capsule did feel less hot after he opened the manual decompression valve at 25,000 feet.

Amazingly, he had performed all the landing procedures to perfection, including turning the night light on, opening the decompression valve at 25,000 feet, attempting to jettison batteries to slow his descent (all but one battery failed to release because of an engineering error which would have caused serious difficulty had he remained at altitude that night), and released the balloon upon ground impact with perfect precision timing.

An hour later in the Base Hospital, his ECG showed no obvious abnormality and his pulse rate had dropped from 180 to 140 beats per minute. By then his internal temperature had dropped to 100.2°F. He seemed alert but understandably tired.

He was given intravenous fluids with electrolytes and seconal to insure an undisturbed night's rest. The following morning he was his usual alert, bright, cheerful self, full of vim, vigor, and enthusiasm about what had happened, and eager to delve into the details.

At the debriefing that afternoon, when the question of MANHIGH pilots failing to eat and take liquids in adequate amounts was being discussed, Lt McClure volunteered the following comment:

"As far as I am concerned about taking in food or water, the situation that you are put in from 80,000 feet to 100,000 feet, and after then at altitude, was such that only a person who just really never cared even about looking with his eyes could stop to eat and drink, and that was something that just ran on until you almost fell over and you realized, well, if I don't eat and drink I won't be able to do any more."

Later in the debriefing, Lt McClure described the manner in which he conserved his energy during the descent:

"So I leaned over with my head against the spot photometer, and when I went to tune the transmitter or anything, I was real careful to be extremely slow, and I didn't try to do anything I knew I wouldn't have to do, and I would try to relax and go to sleep that afternoon. To think that my feet would be relaxed, to relax my hands, tried to make my back feel the same way, and my neck, just try to drop everything except what I needed. And still, I could feel my heart pounding all in the top of my head, but it was awful hot - If you know what I mean, your heart no longer beats without you knowing it and your pulse is transmitted to the brain and it kind of hammers in the top of your head, and I was real hot."

Discussing the visual aberrations that he observed during his stress experience, Lt McClure pointed out that approximately two hours after he left 95,000 feet (approximately 1700 hours) he emptied his bladder so in the event he should experience a rough landing for some reason or another, he would prevent the possibility of bladder rupture. He went on to say:

"So what I thought was about two hours after 95,000, after doing a little work for you people - very little, you were so considerate - I closed my eyes again and all I could see was little blue and green flickers of light - it was generally more like aurora or something. It was an area of light that came and went."

INT: Under stress, in fact, under extreme stress some people see virtual images, but they appear so real that you can almost reach your hand out and touch them.

Lt McClure: Oh, no, it was nothing like that. No, it wasn't any image at all - no, these things were just splotches of light that came because I was so blamed hot.

INT: They had no form or position?

Lt McClure: No, it was just the flashes right through, only when I closed my eyes at first, and then after a while, well, I would say another half an hour, was the worst, it just got solid when I opened my eyes or closed them.

INT: Did you see things through them?

Lt McClure: Oh it inhibited a little bit, but I couldn't dare look out, if I looked out the porthole, boy, it really got bad.

INT: Did this get better?

Lt McClure: Oh, yes, even though the rectal temperature never dropped until I touched down and got out of the thing, and then I'm not sure.

That he was able to execute the complicated procedure of landing the balloon in his state of stress was very remarkable. During the debriefing, he mentioned a number of things that had filled his mind during this landing period. He had considered at great length the possibility of the capsule landing on a steep sloped mountain side and rolling or tumbling, and the similar complication of the capsule landing on the edge of a deep-cut arroyo on the desert floor and falling in upside down after release of the balloon. In either case, he realized it would be a critical error to release the capsule from the balloon before the capsule had come to rest. He further considered the implications of the liquid oxygen reacting with the aluminum should the capsule suffer damage on landing. He was still able to project the situation and assess hazards realistically.

The skin resistance pattern during the first 5-1/2 hours of flight (prior to the severe heat stress) and the first 8 hours of the confinement test show essentially the same pattern. In both cases, resistance started low, around 10 ohms and gradually but steadily increased to approximately 30 ohms. No skin resistance values taken during a heat stress comparable to this situation are known at the present time. The gradual decrease in

skin resistance through the afternoon may be a reaction to that stress. During the confinement test, however, the resistance gradually climbed through the test, reaching a maximum value of 70 ohms at time of termination (Fig. 37 and 48).

Lt McClure's pulse rate after reaching altitude steadily climbed from a moderately high value characteristic for him, 110 beats per minute, to 180 beats per minute, after which it remained constant at this physiologically maximum value. It is unfortunate that the respiration sensor failed to function after 1245. Before that time, there was a light variation in respiration around the relatively high average value of 25. The humidity ranged between 50 and 60 percent throughout the flight.

It should be noted that a significant contribution to Lt McClure's successful completion of the flight was to the excellent job done by Captain Beeding in briefing Lt McClure on unusual situations and capsule operations and limitations during his 24-hour chamber run at Wright Field.

The subjective ratings rendered by Lt McClure during the flight are presented in Figure 48. It is most unfortunate that the subjective ratings had to be discontinued because of the excessive heat stress following 1200 hours, just when they would be of greatest interest. It is of particular interest that at 1200 hours, when the capsule temperature had already exceeded 90°F, Lt McClure registered his subjective feelings as comfortable, not even warm. This is a strong commentary on his intense motivation and drive to perform the experiments planned at altitude. He utterly refused to admit to himself that his opportunity to remain at altitude was being threatened. The observations he was making were apparently of such intense interest that his physical discomfort and thirst didn't get through to his conscious mind.

In his presentation of the MANHIGH III flight, Captain Beeding* emphasized that our selection procedure, although not perfect, had given us a pilot who was equal to the rigors of the flight - rigors far in excess of what had been anticipated. He also pointed out that in these space-equivalent type flights it is essential to schedule food and liquid intake because the pilots consistently are too emotionally keyed up and intensely interested in the experience to properly attend to their nutritional and liquid intake needs.

*Beeding, E. L., "Stress Aspects of the MANHIGH III Balloon Flight", Presented to the Annual Aeromedical Association Meeting, April 1959.

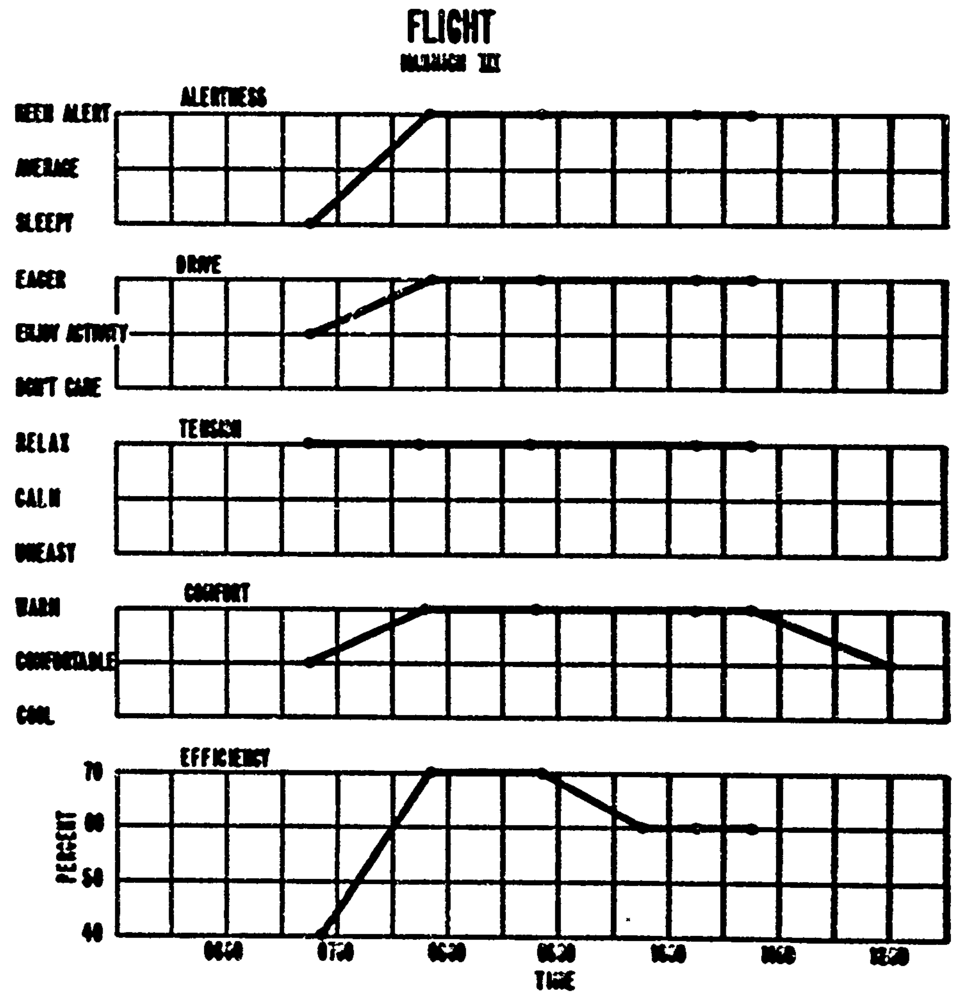


Figure 48. Subjective Operator Ratings During MANHIGH III Flight

Discussions between Captain George Ruff, Captain Beeding, and myself brought into clear focus the importance of selecting an individual who would be capable of handling not only the planned flight profile, but any emergency that one might envision. It is absolutely essential that the individual selected be competent both in knowledge and emotional stability to handle the situation alone totally without communications. Lt McClure was considered very nearly an ideal subject for this type of mission. He was primarily a scientist and engineer with his motivation primarily in these areas, but with pilot training and experience. The tremendous importance of this motivation factor could not be brought out more clearly than it was on this flight. His obliviousness to his physical discomfort because of his intense desire to make the observations at altitude demonstrates the depth and intensity of this type of motivation. It also can be a hazard if indulged without adequate spread of attention.

It is interesting to note throughout the story of the MAN-HIGH III flight, as seen by those responsible for its success on the ground, that the telemetered physiological data were of tremendous value in identifying problem areas that had escaped the attention of the pilot and in giving them a tangible, though tenuous basis because of incomplete coverage, for making decisions when verbal communications failed.

D. CONCLUSIONS

The selection program described here was a pioneering effort at correlating the various physical and psychological parameters that need to be considered in selecting an astronaut. It served as a preliminary model for the program later established for selecting the Mercury Astronauts.* If this program has emphasized any one feature, it is the outstanding importance of presenting the candidate with as realistic a combination of conditions simulating the actual flight experience as possible.

This flight demonstrated clearly the fundamental importance of selecting an astronaut who has the innate interest, intelligence, and basic scientific training to understand his vehicle and the challenges of its environment. Motivation to participate in a flight to "accomplish the mission as directed" is inadequate. The astronaut must be primarily motivated by the challenge of the opportunity to explore the unknown as a

*Ruff, George E., "Medical Criteria in the Space Crew Selection", Presented to 108th Annual Meeting American Medical Association, 9 June 1959.

scientist with adequate engineering training and flight experience to permit him to execute the mission. If this is disregarded, one would expect from the experience of the three MANHIGH flights that only a part of the potential scientific value of a given space mission will be realized and the chances of the astronaut successfully meeting the unexpected crises of space flight will be greatly reduced.

The integrated physiological, subjective, and psychological studies made on the MANHIGH III candidates and on the pilot during flight, was the culmination of three years' of effort in developing methods for correlating the psychic state of a subject with his measurable physiological condition under the stress of a space flight situation. It was a pioneering effort in the field of psychophysiology. As man ventures into space, the importance of knowing an astronaut's performance or efficiency level, and his mental and physical reserve by means of telemetered bioelectric data will become increasingly important. This requires integrating such specialized fields of knowledge as electrocardiography, various body temperatures, skin resistance changes, and psychiatric decrement under the prolonged stresses of fatigue, isolation, confinement, pressure of critical observations, and need for a high level of alertness. The meaning of these measures can be adequately determined only through an integrated program of ground space cabin simulator studies and space flight experience.

This flight under space equivalent conditions was the first to use a "Panel of Experts" to supplement the knowledge and acumen of the pilot. This technique provides at least twice the return of useful scientific information from a solo space flight than the previous method of preflight briefing, then postflight debriefing and discussion.

CHAPTER V

PILOT'S REPORT*

Preflight procedure began for the pilot on 7 October 1958 at 1330 when one seconal tablet was taken to insure sleep. I awoke at 2030, and at 2100 ate a large meal consisting of steak and potatotes. I arrived at the Aeromedical Field Laboratory building at 2230 and began immediately to dress in the pressure suit. The pressure suit was completely donned by 2345 and the sensor circuits were checked out shortly after midnight.

The next step was placing me in the capsule and establishing the seal and cabin atmosphere. Up to this time the procedure was "old stuff" and no particular mental reactions were noted; however, I was fairly certain that the flight would go. Establishing the atmosphere was normal and I went through it routinely. Everything was normal until 0315 hours when Captain Beeding asked me for another check on the pO_2. I reached to my right and as I did so, the parachute, for no apparent reason, released itself with a muffled "flump".

This event caused considerable mental and physical strain before it was satisfactorily resolved. My immediate reaction was that of complete surrender, knowing the time element that would be lost if the seal had to be broken, a readily available chute exchanged for this one, and the atmosphere re-established. I felt that this precluded the flight, at least on this day. Also, I knew that the big gears were in motion and all efforts were being expended to complete the other necessary phases of the flight; I was afraid the balloon procedures may have gone too far to be easily reversed. The feeling of surrender passed in an instant but was replaced by one of complete frustration that was to last several hours.

I decided to notify Captain Beeding and Colonel Hessberg for their decisions and had picked up the mike within 15 seconds after the chute deployed, using only enough time to take it down from the wall hook and carefully place it in my lap. Then, as Captain Beeding answered me, I realized that this would allow no decision if given to anyone else. I was the only person that was physically in a position to evaluate the possibilities of repack; anyone else would be required to make a deliberate safety-of-flight compromise with another man's life, and this is no

*By Lt C. H. McClure

decision. I brushed off Captain Beeding's answer and withdrew into the loneliest corner that I could find during the entire flight. I felt immediate repugnation toward my decision not to tell Captain Beeding because dishonesty seemed to lurk in such a decision, yet I knew at the same time that, again, I was the only person alive that had a decision in the matter.

After about 10 or 15 minutes of tearing debate with myself, I realized that emotion had become more a part of my considerations than reason, and that I had to approach this logically and from a sound basis. Shortly thereafter I set up the criteria for an answer to myself. Whatever the decision - tell Captain Beeding and Colonel Hessberg, push the chute into the bottom of the capsule and fly without it - I decided it must not violate in any small way the following criteria: First, the decision must not endanger the project, and second, it must not endanger my own life any more than the original flight had always done. The plan that best met these conflicting requirements was to repack the chute, and upon completion, to be completely assured myself, that the chute was in as good operating condition as it ever had been or could be. This approach was followed, and after approximately two hours I was satisfied that the repacking had been done. I finished just after leaving the Aeromedical Field Laboratory building on the truck for the launching site and used the time traveling to the launching site for parachute inspection, rest, and to record this series of events on the tape recorder. I verified operation of the tape by listening to this record. I was soaking wet with sweat and began to be very cold as I lowered my activity level and the capsule cooled in early morning air. I therefore zipped up the 2-clo suit most of the way.

I lay over against the chute, now stored in its normal place, and attempted to sleep for a couple of hours while the balloon crew put the final preparations on getting the big balloon up. I was not able to go into complete sleep, as I had been the day before, but the rest did help me. I was now completely over the indecisive, frustrating feeling that had occurred because of the chute malfunction, and became mildly excited as the final stages of launch were reached.

The launch itself was smooth and uneventful. In fact, I felt a little disappointed in not being any more elated. The project had become not another job, but certainly just a job in some respects, and with launch this responsibility acted somewhat as a stabilizing agent on my emotions. Another fact reducing the elation of being off was the fact that the launch was slightly sooner than I or the van had anticipated, and I was in the process of fastening the belt for the first 500 to 1000 feet of ascent.

Initial rate of ascent varied around 1000 to 1100 fpm, which was expected. Also in the procedures was the valving off of the gas to a desired rate of ascent of 700 fpm. This was done in four cautious steps of about 20 seconds of valving each, and this rate was fairly well established by 10,000 feet. I had a slight cold and my sinuses gave some discomfort until the cabin pressure began to stabilize at about 24,000 to 26,000 feet MSL. During this part of the ascent, blowing my nose produced mostly blood. The pain was not heavy and did not prevent doing any job that I was to perform within the capsule.

During the first part of the ascent I made special effort to compare the out and up views obtainable through the portholes and up mirror, trying to judge the position of noticeable change in sky aspect. The sands, mountains and sky presented an appearance that I was very accustomed to, up to 55,000 or 60,000 feet. Within this range the sky continually grows bluer above, while the apparent contrast at the horizon increases. The view is somewhat softened by the bluish cast given the distant scenes from ultraviolet scatter, but colors in the San Andres were visible during this ascent. I noticed at the eastern base of the San Andres, where they met the White Sands, a couple of little lakes that I had never seen before. These were probably due to recent rains and seemed to be six to eight miles long and about three quarters as wide. These had a decided greenish color to them which was easily seen up to about 65,000 feet. At this altitude the color faded to a dark color not unlike that of the mountains, but their smooth surface made them discernible above this altitude if you previously knew that they were present.

The view through the down mirror was amazingly clear during the ascent, and the entire flight, for that matter. Through this mirror could be seen the light white-brown to reddish colors of the desert, the small specks that were the mesquite and other desert vegetation, the sharp jagged streaks that marked the paths of the dry stream beds, and other details of similar dimensions and contrast. During the latter parts of the ascent, the capsule drifted over the edges of the Sacramento Mountains, approximately above the Sunspot location. The passage from light desert to these very dark-green mountains was also striking through the down mirror. From extreme altitude the division between these two zones was narrow, and therefore added to the unusual appearance of two so widely different terrains existing so near each other. The down mirror gives a view almost directly vertically down, yet even through this mirror the relief in the mountainous terrain was clearly evident. Also visible were the variations in wooded

densities. The valleys were plain in relief and usually marked by a stream bed which was a small white line winding its way downward to the desert.

At 24,000 feet MSL I gave a pilot report which included the capsule temperature from the instrument panel. At this time the reading was 89°F. From the tapes, I find that I apparently agreed with myself and with Captain Beeding to disregard this gauge because "obviously" it was incorrect as evidenced by the high reading this early. I stated that I felt a little uncomfortably warm. I found that I had taken the "job" I had to heart so strongly that I was making more effort than was necessary to try to make the flight more effective. I noted (passing through jet stream) this undue effort on the tape and made an effort to relax and take every fact of the job in order, and thereby save energy for the total long grind. At about 55,000 feet the cabin temperature read 94°F, and there was some discussion between the ground crew and myself and we finally concluded the gauge was off. The telemetry said 76°F at this time. I stated that I was warm. The feeling was only that, warm, not hot, nor particularly uncomfortable.

The capsule had quite a bit of rotational instability, rotating from one-quarter to one turn in one direction, and then stopping to go back the other direction. Up to 60,000 feet it favored the right rotation, and above that altitude the left was predominant.

As the system approached altitude the rotation gradually slowed, and after reaching altitude, almost completely stopped. When at altitude, any movement created an oscillation of the vertical axis of the capsule. This motion was very evident and seemed to have its axis just at or above the top dome. I began to see the "space" sky very definitely different at about 85,000 to 87,000 feet. Here the sky had really lost its blue coloring, or lost coloring altogether and had become a completely dark void. The main sky-aspect change from this altitude to ceiling was in the horizon zone. This area got narrower and of higher contrast with the dark sky above it as we ascended higher. The horizon was never a definite earth-sky meeting, never a sharp zone, but was an area below which earth existed, and above which the sky was apparent. The earth and sky separation was performed by a very bright band of atmosphere, apparently lying out near the horizon and very effectively obscuring the earth-to-sky junction. This band had the appearance of a bright circular tube of light lying above the earth, and I referred to this as the halo zone

several times thereafter. This halo zone existed from below the earth-sky junction to above it (I would guess about equally spaced above and below this junction) and was about 5 degrees to 8 degrees in total width.

The view varied greatly from directly down to directly up, but I will attempt to explain it. Through the down mirror the view was always very clear and sharp, apparently out to about 25 degrees from straight down; this was about the cut-off angle in looking out the portholes. In the view down through the portholes at this maximum angle, the details were still very sharp, and only a very light haze was apparent from here on out to about 35 degrees. However, at 45 degrees down view, the haze reduced detail. The features recognizable became mountains, the Rio Grande, White Sands, and the lava beds. These items could generally be distinguished about 15 to 20 degrees below the horizon; however, for the last 15 degrees up to the horizon, the bluish-white haze increased so that little detail was visible. This haze graded into the very bright white zone referred to before as the halo zone. Just above the halo zone there was a layer of blue, grading from the lighter blues (normally noticed at the horizon) to the heavier blues (as seen at the zenith position when viewing from sea-level) and rapidly into even darker blues and space-black. This whole "blue-zone" is about equal in width to the halo-zone, or about 6 to 8 degrees in angular dimensions. Looking above this angle into the sky immediately impressed me as the blackest sky I had ever seen, yet - and this is completely beyond my own poor power to express - this black continued to get blacker as I elevated my gaze. The darkest area was vertically upward through the mirror. Upward also provided the sharpest color contrast imaginable. The balloon was a snow-crystal, shimmering white, so bright that it alone was difficult to look at. This bright object was directly contrasted with the deepest space-black beyond it, and this contrast was so great it caused discomfort in the eyes when looking back and forth between the two. In fact, after having the mirror positioned so that only the space-black was viewed and then moving the mirror over to view the balloon, the effect was the same as when coming out of a dark movie into the noon sunlight, and several seconds of squinting were necessary before the eyes could comfortably accept the new light level.

Shortly after reaching altitude and performing the routine pilot's report and taking some pictures, Dr. Ruff came on for an interview. We began with the very normal frivolities of any conversation but shortly, somehow we had moved into the area of deep subjective feelings. This conversation will probably be much better written in some other part of this report; also, it will

be available as a transcription included in the report. However, I will make an effort to put down my feelings at that time. I suppose the beginning of the conversation came when Dr. Ruff asked if I was thinking at the moment about anything other than what I was looking at. The answer essentially stated that even though there was a tremendous enjoyment in what I was doing, I found a persistent feeling of insecurity. It had also noted this feeling in the smaller balloon rides. Lee Lewis and myself had even discussed this and found that it was present even in the old balloon pilots, as represented by himself. Essentially the feeling was the same here; it was due, I think, to the fact that normal references, normal support, are gone. In a balloon there is no visible means of support, unless you look almost directly up, and it seems that no assurance comes from this because in doing so all normal references - horizon, ground, et cetera - are completely lost with the act of looking for the support.

There was another feeling that persisted during the time that I was at altitude. This was very similar to the just described feeling of insecurity but to explain it more exactly would be to describe it as a "reverent" feeling. More than once, as I looked out on this strange scene, I recalled the often used words "conquer space", and came to the conclusion that this was a very inapplicable phrase to apply to this region which I viewed.

Lee Lewis came on and I had a short conversation with him. He was very elated over the smooth launch and climb, and with the worst over and no apparent problems, he was expecting a very easy, perfect flight. This struck me as just a little out of text. I had no forebodings of ill, but I made several statements to the effect that the flight was not over yet and could not be considered smooth sailing until completely ended with the landing accomplished. I made a note of this point only because I had made such depressing statements at a time of apparent accomplishment. I had no information nor thought of "trouble to come" at this time. My previous flight experience had several times shown me that when your feet are off the ground you are inherently in an unsafe position and any approach other than one tempered with this thought is not the proper one.

Sometime after the discussion with Lee Lewis, around 1145 to 1200, I suddenly realized that I was hungry. Immediately with this thought came the consciousness of fairly strong hunger feelings and also <u>extreme</u> thirst. I made note of the fact that the engrossment of capsule preparation, launch, climb, and being at su[illegible] an altitude had caused me to forget completely such normal

procedures as eating and drinking. I had eaten on 7 October at 2100 hours and it was now 15 hours later with a continued high activity over the entire time. The only intake during this time was a small can of juice sometime in the early morning prelaunch hours and nothing at all to eat. I immediately took time out to eat, and consumed a tube of chicken, a can of juice and two cookies. The juice tasted especially refreshing and cool, and I recall now that I put the hand from the cool can to my face several times and passed off the fact that I was warm, to be a fairly normal condition for such a flight. I was not as comfortable as I would normally prefer, and if I had been in any normal situation, I think now that I might have registered a small complaint, but here it simply passed as part of the project.

After drinking the juice, I had a request from the ground for a short interview with the press. I had answered several questions from the interviewer when he requested that we start over because of poor communications or recording. I did so, and I found that the verbal dissertation required of me left me fairly exhausted. When finished, I sat back and found that I needed the rest. I was breathing rather fast and could tell that my heart rate was up, a similar feeling as if I had done a small amount of work. The fact that some undue effort had just been expended must have been at least slightly evident over the radio, because Captain Beeding came back with "Man, after that blurb you must be pretty pooped. Why don't you sit back and rest a minute". I felt this was a good suggestion and would give me time to get some water, as I felt I had not completed my "dinner" yet.

I then proceeded to pull up the tube, place it in my mouth and pump up the bulb. I pumped for 20 to 30 seconds, long enough usually, but this time, no water. So I pumped that long again and again. I checked the valve position and the tube, but still no water. I thought perhaps it would take just a little more pumping this particular time so I continued for about two more minutes. The back pressure that was building up in the tank was now evident as the bulb became noticeably heavier to pump. I pulled the tube out as far as I dared and pushed it its full extent back into the receptacle. Still no water. Then I posed the problem to the ground crew; they were stumped for any new ideas, but I tried everything over again that I had just accomplished, to no avail.

The problem suddenly took on new proportions. I knew that I had several cans of juice that would suffice to carry me through the emergency if no water could be obtained; yet I also knew that this juice would not be sufficient to carry the flight as

originally planned, especially with the rate of perspiration experienced so far, so the water had to become available. I had discussed this contingency at Minneapolis in the process of learning the MANHIGH system. I thought at the time that it was a highly unlikely possibility; however, I knew I should think of it in terms of the consequences in case the possibility arose. The problem was not answered easily then, but my idea had been to take the knife and punch a hole in the water tank just about the level that I expected the water to be, and to catch this water in a cup. At best this procedure would be very difficult to accomplish because of the location of the water container, but it was at least a partial presolution. This alternate solution comforted me somewhat but was certainly not a desirable thing to have to do.

Now I began to feel not only that the project would suffer if this water was not available, but also my own physical need for it. I suppose that I had sweated heaviest for the longest period of time in my whole life already today, and I had not replaced this lost body water. I left the pressure as already pumped into the tank stand but now I went for some juice cans and let the tube rest against the capsule wall. Just as I found a can of juice I saw the meniscus of the water lying far down the tube and quickly replaced the tube in my mouth fearing that it would be in a hurry and flow out all over the capsule. It was in no hurry - in fact, the rate of movement appeared to be just above the completely stopped flow rate. I left the tube in my mouth and began to get the wet and dry bulb plastic case out for use. During the time that I was trying to obtain water I had been deferring the other tasks to be accomplished because I felt that the water was extremely important. The van had become very concerned that I get wet and dry bulb readings, I supposed so that they might have an accurate reading on the true relative and absolute humidity in the capsule. By the time I had the thermometer wet bulb saturated and had hung it up to wait to get equilibrium wet and dry bulb temperatures, the water had finally gotten to the end of the tube, and I was getting a pitifully small amount of water - but at least some water. It wasn't running out, only slightly dripping, and I was able to swallow a small mouthful only once every three minutes or so.

I now returned to the water problem to try to increase this flow as I knew that it still wasn't sufficient. This method of taking it also precluded good communication with the ground, as I could not stop the flow. I would have had to remove the tube from my mouth to answer the van's questions. I did not want the water to drop on any electronic equipment; nor, did I

want to waste it by letting it just drip away into the capsule. Therefore I had to sit, tube in mouth, able to perform most operations and to listen, but not very able to transmit. I decided that I should suck the tube. I applied a little pull and a slightly greater flow evidenced itself, but only for an instant. Then a very unusual condition was observed. Almost simultaneously with suction, the tube's contents jumped to life and a series of breaks occurred in the water column. It appeared that the column was suddenly filled with alternate lengths of water and air; the column now contained several air bubbles. I released the tube, very puzzled, and as I did so, the column immediately jumped back to a solid water condition and the answer came to me - vapor lock! Here was something happening before my eyes that was a physical result of the lowered atmospheric pressure within the capsule. I applied suction again; the obedient little gas-bubble soldiers jumped to attention, serving effectively to stop the flow; I released and they again magically disappeared. This fascinated me for several seconds before the realization came - this is no solution. I must get higher water flow. Since I had been able to consume some, I waited about five more minutes for a couple of mouthfuls, and then began to experiment with hose positions trying to trace them to the container. Finally I gave up and just started pulling the tube out. I stopped after I thought I surely had pulled the tube out so far that it would come out of the container. Just as I did so, the flow suddenly jumped to a very high rate and served almost to choke me. The problem was not solved and I consumed as much water as possible in case the situation occurred again.

During this time, the van had requested that I take my own pulse. I did so. My pulse was 128. I knew that this was high but it made no particular impression. We were off schedule because of many small things, and I wanted to return to and clear up these items. I proceeded to shoot out all the anscochrome movie film so that I might load the camera for an Eastman experiment. I had been alerted during the water problem for possible observance of high altitude missile burst, and now while loading the camera also was trying to orient myself with some known items on the ground. White Sands and the lava beds were behind me, the San Andreas just directly below me, and all of these references were very difficult to view because of their position. I noticed that to hold the K-100 camera up to the window tired me slightly.

Captain Beeding asked if my heater switch (or as the switch was labeled on the control panel, "air conditioner") was in the center or off position. I checked it; it was neutral. I looked

up to see if I could flick it on and off and get corresponding increases and decreases in the meter. I did get those verifying the off position. I turned back and reached for the air regenerator hose to direct its flow onto my face and on switching from window-directed flow to hose flow, I got a blast of very hot air from the hose. On replacing the hose, I became immediately aware that the cabin temperature gauge had been reading high because it was situated just above the hose outlet and was reading the high temperature of the air. I called back to tell Captain Beeding I knew why it was reading high, and he told me he knew it was reading the air regenerator temperature. I didn't remember then that the sensor for the temperature gauge was sitting on top of the air regenerator box, but we were now aware of the reason for the high temperature reading. I got the dry bulb reading at 96° - I didn't believe it - Captain Beeding had to have a couple of repeats on this as if he didn't understand me. Then when he understood 96°, he said simply, "Take another drink of water".

It became obvious to me that considerable discussion was going on. The delays in answering my transmissions were much longer now; different people answered as if it was whoever was nearest the microphone. Captain Beeding came on and I told him I was going to start to get the 1400 position report. He said to sit back and take it easy. This bothered me considerable as I knew we would drag further behind schedule, but Captain Beeding made a point of insisting on this. The C-47 asked the van for my pulse rate; it was 150. The van then asked me to check my own pulse rate; I got 148. In tuning the omni for better reception I had found that the metal face of it was too hot to touch comfortably. Since I had been told to rest, I felt I might as well try to lean carefully over against the parachute, taking care not to lean on the photometer.

Shortly Colonel Hessberg came on and I was completely surprised - in fact, somewhat amazed - to hear him say that the decision was to have me descend to a lower altitude, that we must cool off. The fact that this would come up had never occurred to me. There were only 3-1/2 to 4 more hours until sunset and it would take me almost that long to descend to any altitude that would give me any aid. Since surely heat would not be a problem at night, the least we could do was to wait out the time till dark and thereby get in most of the work. I made a request to inject these opinions for their consideration. I was allowed to do so, and after only short discussion again, Colonel Hessberg told me that we must descend, to a lower altitude to cool off. Lee Lewis took over and advised for descent with his apologies, yet also his concurrence in this decision. I still did not concur

but decided that if I could lose only a slight amount of gas to provide the descent called for, and was careful to control this descent so that it wasn't rapid enough to take in air, I could still easily return to altitude with loss of perhaps one additional battery later on during the night.

The valving began with a 4-1/2 minute, both-valves-open shot. The advice from the ground was that it would take some time to initiate descent after the valving. I understood completely, intending to wait as long as possible to observe the beginning of the descent, for two reasons. First, if I was going to descend I wanted very much to do it properly and always under complete control. I was convinced difficulties with balloon operation are usually the result of over control. Second, I knew that these necessary delays were delays that allowed me to stay at altitude a little longer and would also result in a higher altitude on termination of this descent, allowing an easier return to maximum pressure height during the night or the next day. I was not considering a complete descent at all.

The time was now about 1330 and my rectal temperature was approximately 102.8°, with a heart rate of 145 to 148. These items did not impress me as being impossible, as my pulse rate had been recorded this high previously. I was in such a state that activity tired me greatly; I decided to conserve my energy, keep up my water level and perform the descent as accurately as possible. This would tend to make my return to a high altitude more possible. From this time until about 1410 I spent alternately valving and waiting to see what effect the valving would have. By then a very slow descent could be detected. I remember looking at the clock at 1410, then leaning over to rest against the parachute, disturbing my rest only to valve or read the altimeter as directed. I made a mental note to read the clock again in about an hour. I looked again when I thought one hour had passed, and the time was 1428 - slightly less than twenty minutes had gone by. The effect of this slowing of time was very marked on me. The condition I was in was becoming more difficult to bear, enough so that I imagined much more time passing than usual. The time began literally to drag by, and the clocks slowing became as much an enemy as the real conditions that were causing my problem. I now concurred with the decision to cool off; however, the descent still did not seem the solution. A statement made by me at the time to Lee Lewis indicated my conception of the situation, "I'm glad I don't have to make a night landing".

I continued to look out and be completely amazed by what I saw. Once, on looking up to read the altimeter, I caught sight of a striking sight. The red inflation tube was hanging down

from above, seemingly out of nowhere, and was brilliantly lit by the sun and contrasted with the black sky background. A little later I caught sight of the moon. It was standing about 10 degrees above the halo zone on the horizon and compared in surface brightness about equal with that brightness witnessed in the halo zone.

Later during the descent, between 80,000 and 70,000 feet, the sun had descended to an angle low enough to be seen through a porthole. To be able to view the sun, I had included a dark solar filter in my own equipment. However, this solar filter was stowed along with a polarizing filter, in the bottom of the food container, and I felt I was not able to get to it. I wanted very much to observe the sun at this altitude and to see if any of the corona could be observed with the naked eye. I remembered that I had asked one of the photographers for a piece of unexposed sheet film and had put this film in the film container, which was easily accessible. This film was to serve as a rough sun filter, one that I could vary by using different layers of it. Through one layer the solar disc was reduced in intensity but not enough for comfortable viewing. Through two layers comfortable viewing was obtained. The sky remained very black up to the sharp edge of the disc and no filamentary structure was ever seen.

The radio reception had slowly grown worse. The C-47 was the weakest receivable transmitter on the air, and some transmitters were so much more powerful as to make it extremely uncomfortable when they cut in. In fact, once when I had the volume up to a level so that reception from the C-47 was just audible, an airliner came on calling Phoenix Sky Harbor tower with a volume so intense as to leave my head ringing for several minutes. The receiver also began to drift as it heated and had to be frequently retuned. The face of it was so hot that a weted finger placed against it for a few seconds, sizzled. Because of the frequent non-project use of 122.8 we had now switched to 121.5.

Heated debate in the van was obvious to me even though there was an evident effort to spare me the mental strain of being included in it. The frequent pauses in answering my queries, the carry-over of voice inflection and volume into the replies I received, the more frequent changes in people relaying, were very good indications, I thought. The time was 1525, altitude 91,000, body temperature now up to 104.2°, the heart rate 170. The effect of these facts on the decisions from the van as to termination began to bother me. I then injected my opinion that termination and parachute landing in the terrain we were now over was extremely

dangerous and should be avoided if at all possible. Cutting down would be of value to save my life only if we were over open terrain.

The pulsations of my heart, which had been felt since about 1430, were now pounding against the roof of my head, and even the small effort to reach up and to turn the potentiometer to the center position caused a marked increase in this pulsation and tired me noticeably. Now I was too weak and tired to care if I lay against the spot photometer or not, and spent most of my time lying forward and thinking to each part of my body, relax and conserve, a trick I frequently use to relax and sleep at night. This procedure seemed to help. I became concerned lest this weakness become more evident on the ground, and each time I answered the ground queries I put everything I had into my voice to keep it apparently sharp and ready. My voice became a very great aid to me now, about the only one I had. I began to become detached from myself, it seemed. My brain functioned as well as ever as far as I could tell then or can estimate now by listening to flight tapes. I was mentally able even to question the physical cause of my predicament, and I gave the ground this dissertation. It was as if I were two people; one alive and alert, the other dying and unable to respond to the simplest tasks. The lack of response of this physical self to my mental self added considerable frustration.

I had long considered that I would like to observe my face in the mirror, but the mirror was stowed in the food case and I didn't think I could expend the energy to retrieve it. I remembered the polished mirror of the Hasselblad, and did expend enough energy to use it. I had expected exactly what I saw, a very flushed faced, sweating profusely, with an extremely "beat" appearance.

Around 74,000 feet Captain Beeding asked me to put on my shoulder harness and lap belt. My rectal temperature was now up to 105.6. I accomplished this and found immediately that the harness pulled the 2-clo suit up tight around my back and sides of my legs, making me feel much hotter. I requested to take off the harness. Colonel Hessberg refused this request in an exceptionally nice manner, and I again got the impression that the chance of my passing out and being ground-terminated was very high. Again I made comment as to the dangerousness of such a move over the mountains. I definitely did not want to impact, even secondarily, in a negative direction.

I turned the constant flow on in the hope that the O_2 evaporation rate from the converter would increase and absorb some

heat from the capsule atmosphere. Shortly thereafter I asked the ground for confirmation of the chance of this. They agreed and advised me to turn it on; I left the constant flow on for the rest of the flight. Shortly after this I received instructions from Captain Beeding to perform an unusual operation - to keep the face plate handy, but off, and to switch from capsule to suit on the selector switch. I understood the physical nature of the attempt; the capsule atmosphere would expand by being released through the Firewel vent. Expansion implies adiabatic cooling; however, this effect would be partially nullified by the fact that the cooled gas escaped and was not available to absorb heat from the capsule. I performed this operation and as soon as I moved the switch from capsule to suit, a very active white cloud appeared outside the No. 2 porthole - just where the Firewel vent was situated. The cabin altitude began a rapid climb and I immediately closed the switch back to capsule. I felt the Firewel valve cover and it was still as warm as the rest of the capsule walls.

I had not urinated the whole flight and now realized that I had a quite natural push to do so. I knew what an effort was required for this process from the Wright Field experiences, but the need was great, and in the back of my mind was the idea that somewhere in my association with the medical groups I had heard that it was a suspected but unproved fact that a full bladder may burst and cause death in impact type accidents. Knowing the good chance of a high impact, I decided that it would be necessary to follow natural impulses as well as the impact considerations. I set about to perform this task. This job in itself nearly completely exhausted me; where before I was trying to conserve, now I was trying to recover. During the time I was urinating, the ground crew continued its suggestions for proper preparation obviously in case of my passing out and being terminated for parachute impact. The request now was for me to stow the spot photometer.

Just after finishing urinating, I lost contact with the C-47 and could neither transmit to them nor receive them. Finally an answer to my calls came from NCA 40. This turned out to be Lt Roger Winquist of the Holloman Balloon Branch, who was in the recovery control point at Holloman. Knowing that I might lose complete communications if the radio deterioration continued, I gave Lt Winquist my personal plan in order that he, at least would be able to tell the project control officers my plan in case of radio failure. This was the first time that I considered a complete descent. Even now I considered it only because of possible radio failure along with the other problems at hand. If

left to my own decisions, I would, at the time, have leveled at some capsule cooling altitude, rested, eaten food, and drunk water, until after sunset; then gone back to altitude. I knew, however, the control people in the C-47 were becoming more and more concerned about my condition and might even request a full descent even if the capsule were now to cool to normal. Lt Winquist repeated the plan for personal descent after much effort on my part to transmit this to him, and I returned to the task of restoring the urine bottle to its proper place.

The C-47 communications returned before I was able to stow the bottle, and the voice from that end was now almost militarily insistent that I stow the spot photometer. I was now becoming extremely exhausted and wanted to defer this task, but when I was unable to return the urine bottle to its place, I gave up, dropped it on the floor and went at the photometer. I was completely exhausted and only with a great effort was I able to sit up. If I had not practiced the removal of this instrument, I probably could not have gotten it loose, but I crossed hands and pushed hard against the pin holding it. It came loose immediately, and simultaneously I felt a terrific desire not to drop this instrument. However, I was too weak to hold it and it crashed to the bottom. I had remembered that the bag I had been insistent on having was put in specifically to hold the photometer on the floor and away from the foot switch so that normal communications could be kept. Now the photometer was lying precisely where it shouldn't - making the foot switch inaccessible.

Captain Beeding now was asking about the photometer, "Has it been stowed"? I tried in vain to answer him; then I tried to pick up the photometer, but felt that I would not be able to hold it, and there was no place to put it. The effort was more than remained in me. I could not lift this seven pounds of instrument. I tried to flip it over, away from the foot switch, but there was not enough room in the bottom of the capsule for my feet and legs, the urine bottle, tape recorder, and felt boots. I then found that I could get a transmitter click by rocking the photometer over toward the right with my foot; I could operate the transmitter switch with the photometer itself! If I had had enough energy I would have screamed out an answer to the C-47, but this was not possible. Now I was just barely able to muster an answer, much less to make the voice defense that I had kept up so long. I answered Colonel Hessberg. He didn't receive me. I answered him again and again. He ended up giving me another long count.

Now I realized that something had to change. The bright porthole area was not very different from the rest of my field of vision. It was all bright; there was only a little greener

cast in the shadow areas inside the capsule away from the portholes. I was unable to sit up, except with extreme effort, and then only for a few seconds, but falling forward provided no relief now. The floor was cluttered and there was no place for my feet. The elevation of my feet, because of the items on the floor, caused strain in my legs when leaning forward. It was no longer possible to get any relief and rest by closing my eyes, for when I did, very uncomfortable bright green flashing areas filled my vision, as if I had only bright lights to view. These flashes were less disturbing if my eyes were open. I decided to relax and listen to ground instructions, just so that I might be more informed. This also proved to be impossible. Every call from the ground invoked an involuntary effort to reply; the inability to reply frustrated me and I finally realized that continued effort simular to the last 20 minutes would surely cause me to pass out or die. Therefore I pulled out my communications plug. The silence was absolutely startling but unbelievably welcome. I could now concentrate on repairing some physical ability to operate. The silence and complete inactivity seemed the means by which I might be able to do this.

My heart rate was about 180, breathing was fairly heavy and I knew that much more activity would cause me at least to faint; more than ever I felt the separation of mind and body, and it was almost an eerie feeling to let my mind wander off to some cool spot and to sit there and watch the body slowly and helplessly going into thermal oblivion. I lay as comfortably as possible against the parachute and was completely limp and exhausted for at least 30 to 40 minutes. Then I made the small effort of lowering the drinking tube down to my mouth and pumping the bulb up; I lay there now very slowly taking on water and continued to absorb it long past the point of being full of it, because I knew that my internal water supply was very much depleted. I stopped only when I felt that I would vomit with any more intake.

The communication failure occurred at 1710 hours at about 59,000 feet and with a rate of descent of 400 fpm, and now it was 1750 hours. I had recovered from the very uncomfortable bright flashes and the feeling of going out from exhaustion. My mind had turned over and over the various possibilities and consequences of my position, my condition, and any errors that I might make. Several new aspects of the problem presented themselves, and by the time I began to feel as if I would not go out, I had a concrete set of plans for what I felt were my only choices.

First, I now knew that I would have to perform the ground termination at the end of this descent. This meant a night

landing, and since I was not sure of my position, heading or speed, possibly a night landing in the mountain. To this I had what was to me a unique solution. I knew that I must land with a controlled rate of speed and remain upright, no matter what type of terrain I landed on. A secondary negative impact, as might occur if the capsule toppled from the side of a cliff into a ravine, could provide the most dangerous situation. This condition had been the worst preflight emergency that I could configure; it was so bad that I had resolved to level off at about 10,000 feet over the terrain if I found myself landing in mountainous country. I would then hold altitude until I drifted over a more desirable spot to land. I had decided to follow this procedure even if it meant total ballast drop to level off, taking a chance then that I could satisfactorily valve my way into more suitable terrain. I had never considered landing in any mountains under any conditions but now I was faced with this possibility. With this consideration I decided to make a very normal and very cautious approach to land at 200 to 300 fpm as a desired rate of descent, but that I would not ballast to obtain this rate unless I was above 400 fpm. This was as prebriefed. However, I planned to determine in the few seconds of initial ground contact whether or not to release the balloon normally or to retain it. If I hit normally, remaining upright or falling over and remaining that way for a few fractions of a second, I would consider this a solid normal contact and squib the balloon. If I hit on a slope or on the side of a very steep wall, I hoped that I would be able to feel the sliding or rolling effect received and be able to distinguish this contact from the desired solid impact. In this case I would retain the balloon. If I retained the balloon its lifting presence would stabilize the directions of possible secondary impacts so that the chance of negative application of these impacts would be greatly reduced. I hoped then to impact, slide, retain the balloon and even to bounce the two or three thousand feet expected, and then, knowing the altitude of first impact, to open both valves 300 to 400 feet above the altitude on the way in the second time. This landing would be a series of shorter and shorter bounces, working the capsule slowly down the slope, to terminate when the bottom, or solid impact, was reached.

I considered the possibility of a mountain peak or cliff edge ripping the bag and rapidly but not immediately drop me. I thought that there was no choice other than to accept this possibility. If I impacted and could not decide positively that I was on solid flat ground or on sloping steep ground, I decided that I would do at least one high bounce that would give me a few more seconds and another impact to decide. The second impact would probably not be too bad and I could terminate on it.

If the ground control terminated me, I decided to blow the capsule apart at 22,000 feet and slowly and calmly step out at 15,000 to 20,000 feet after pulling the red apple. The procedure was as prebriefed and therefore the ground crew would know exactly what to expect.

These considerations included all possibilities for termination that I could imagine. I also realized that the only indication of personal condition, now that communications were out, was the balloon performance. I resolved to accomplish this so that the command group would have no cause to believe that I was in any other condition than the condition I was in on our last contact.

I continued to make only the minimum effort necessary to make the descent and landing. I reset the potentiometer to zero deflection and decided not to touch it again until landing so as to remove this small effort from the list of energy consuming necessities. The temperature reading as it was last set was 108.7°F. The potentiometer needle had deflected more by impact time but I did not read it. The only energy consuming tasks that I allowed myself were to read the altimeter and vertical speed, and valve and ballast as necessary for balloon control. I had gained enough strength and lost the vision difficulties by now even though my body temperature was still rising and the capsule was still as hot. However, it was not getting hotter. I allowed myself to perform the last termination rites by stowing every other loose item, including the Hasselblad, into the bottom of the capsule. It really hurt to put the Hasselblad away, and I shot the remaining film quickly as the sun was near setting. The altitude and time was respectively 38,000 feet and 1740 hours.

The vertical speed was now a very steady 1000 fpm, having stabilized at this new rate from the 400 fpm I carried in the stratosphere. This rate was by far higher than I intended to impact with, and as the sun was now setting, I knew that the vertical speed would soon increase. I wanted to place all my current thoughts on record so I unhooked the dictet microphone from its capsule hanger and set it in my lap within easy reach. I recited all my considerations and thoughts and all activity within the capsule for the record. I started to retrieve the dictet itself from the bottom of the capsule and to install a fresh tape for the descent and to check its operations, but energy and activity considerations stopped me from this and I forced myself to accept the fact that it was operating.

The seat became very uncomfortable with my feet elevated from the floor level. The many items stowed on the floor caused this lifting of the lower part of my thighs from a large area of the webbing of the seat. This increased the sitting pressure on my buttocks and made sitting in this one spot very uncomfortable, even though I only had one or two hours that way.

Just as the sun set I lifted the guard on the ballast initiator and selected 12-volt battery No. 1 on the selector switch. I had decided to wait until the vertical speed began to increase, even the slightest amount, and then to ballast this battery. This happened just before the sun was fully set and the vertical speed was 1000 fpm when the first battery was blown off. I noted the time, altitude, vertical speed, and which battery was being blown on the dictet, and also the time again when the vertical speed began to drop and at what value it restabilized. When I blew the first battery, it went with a loud "spang", a light red flash and considerable oscillation of the capsule. Within four or five minutes the vertical speed dropped to 900 fpm or a little less. I thought that this small response was due to the continued natural intent of the balloon to descend faster with loss of more super heat. I decided that 900 fpm was slightly fast and that I might start early to approach the more normal impact speeds; I selected 24-volt battery No. 1 and "spanged" it off as before, holding the dictet against the metal wall of the capsule to record this event. The red flashes and capsule shaking were evidence enough for me that this ballast was away. I became somewhat concerned about the tracking crew below me in aircraft and choppers but dismissed this with the thought "I have my problems, they have their problems".

I really felt proud that I had been able to out-guess the balloon, for now the vertical speed remained precisely 900 fpm; I thought this indicated exact compensation of loss of super heat with ballast. After allowing the balloon to descend a couple of thousand feet to be sure tha it had reached a state of equilibrium, I started to ballast to reduce the vertical speed to the desired landing value. I selected 24-volt battery No. 3 (No. 2 was not selected here because it was a double ballast load of about 100 pounds) and on initiating it I got only a muffled sound; no oscillation was imparted to the capsule. I decided to descend another 1500 feet to be positive. I would make all decisions while lying forward against the parachute and was extremely slow and deliberate with all movements. Even when performing the necessary tasks I would lie against the right side of the capsule and try to rest. After descending another 1500 feet the vertical velocity was still the same, and

I chose 12-volt battery No. 2; it apparently went with normal indications. The vertical rate did not change. After another 2000 feet or so I selected 24-volt battery No. 4 and upon initiating it I got absolutely no response, and shortly thereafter got the same with 24-volt No. 5. Then I lay forward for awhile trying to see if I could find an answer to the problem of why these items had malfunctioned. No answer came and I could not think of any means to trace the ballast circuits for possible trouble check. I considered that the selector and/or initiator switch were not making contact, yet some batteries had gone, indicating good contact. Since I knew also that I could not afford the effort to make any sort of investigation involving any prolonged activity, I dismissed the possibility of a trouble check. I decided to try to find at least one battery that would go out of the remaining ones so that I might fulfill my intentions toward reducing the vertical speed. I then switched over to internal emergency battery on both 12-and 24-volt systems and turned on the rotating beacon, as I was now coming down below 30,000 feet. The selector switch positions to blow all remaining batteries were alternately chosen and initiated, but no response was obtained. I thought that I heard one small unusual sound on initiating 24-volt position No. 9 or No. 10 but nothing definite. I concluded that I had no other ballast available except possibly the double weight ballast No. 2 on 24-volt battery.

I then took a long rest, some of which was done lying against the right side and looking out the No. 2 porthole. The mountains to the west were still sharply silhouetted against the background glow of the western sky. These loomed up so large that I decided to be prepared for the worst; I would land in these mountains. However, I could not tell if I was drifting toward or away from them now, as I had been able to tell when it was lighter. I could now see several towns, apparently to the east. I could never decide if these were Alamogordo, Carrizozo or Artesia. The more southerly town had a very beckoning beacon and I remarked to the dictet how I would prefer to land near this beacon; however, I was more concerned that if I came this close I could easily come down in the town itself, and I definitely wanted to avoid this. In watching the light patches that were towns in the distance, I found that I had started using them to help judge my altitude. I also established the idea that if I should descend below a mountain peak, the cutoff of these lights might indicate this and prepare me for impact. I had no ability to judge height or see the impact coming otherwise.

At 24,000 feet I got the only instant of real confusion or panic on the flight. I had established the use of the lights to tell me if I descended below a mountain peak; however, I had

decided the maximum height that this could occur would be 12,000 feet or lower, the maximum height of the mountains in the area. However, the lights suddenly vanished before my eyes at 24,000 feet of altitude, and for an instant the present plans were completely disrupted. It took me a few seconds to discard the fact that no mountain could have intervened, especially for two such widely separated towns. I concluded it must be a cloud layer, yet I had not seen one on the flight and could not see one now. Shortly I came out of this condition and apparently had gone through a very heavy haze layer.

From 24,000 feet down to 15,000 feet I went over again and again all landing possibilities. I located the top and bottom Marman clamp release switches and the balloon squib initiator switches many times, both with lights and in the dark.

I reached back to open the manual decompression valve at 23,000 feet and got a terrific pain and cramp in my muscles of both thighs. This pain almost doubled me up but I forced myself, in spite of it, to take the valve cover completely off. The pain continued to come and go and seemed to be just a cramp caused by my unusual leg position. I now monitored the pO_2 closely as I descended. It remained very high and I stopped monitoring it at about 18,000 feet. Somewhat below this altitude I performed the landing procedure of closing the air regenerator valves and shutting off the blower. The windows immediately fogged over and could not be wiped fast enough to see through them; I decided to forget the outside and simply wait it out following my own plans.

I had been dict-ting all the movements and mental ideas to the dictet and it became my companion that provided for data storage. I suddenly realized that it provided communications to the outside, even if of a delayed sort, and that the only use I was making of it was as communication to myself. I imagined that it provided a way to review the flight after I returned to good shape. I realized that in the situation it would perhaps be normal to leave some note on this undying tape, since it would surely survive. I became aware that I had considered the things that might cause my death in an almost unholy passive way; from a review of the tape it might even seem as if there was no apparent difference between my existence on this or the other side of death. It disturbed me somewhat that this little parrot that I was speaking to might leave such an impression, and I made some comments to try to leave a true record of my feelings. I had, during the whole project, considered many very disastrous results - to overlook them would have been foolish - and this continual association with the idea of certain emergency events had

reduced them to objective evaluation. Now it was the same, except that the conditions were more concrete. I was not praying to live or even concerned that dying or being injured was so definite a possibility. I remarked that I felt I had plans and the capability to augment them that would allow a reasonable probability to accommodate my unusual position. If I had not been satisfied with the abilities of myself and the facilities at hand to compensate for this situation, I would have made other procedures that should have provided the compensation. In short, I thought that my outlook was the exact opposite of fatalistic.

The vertical speed varied between 850 and 900 fpm and I decided I would not initiate the large ballast unless I got an increase to 1050 fpm. I felt that the impact could be made at 700 to 900 fpm and that if I used the single large remaining ballast, I must use it at a speed which would be high enough to insure a continued descent after ballasting. At 12,500 feet I set a light on the instrument panel to be able to see the altimeter and vertical speed, and leaned over into a very secure position kept tight with the safety belt and shoulder harness; I selected the position for the large ballast and placed my thumb on the ballast initiator switch, lifted both guards on the ground termination and termination actuator switches, and carefully slipped both fingers under the guards. I sat viewing the altimeter for impact and possible termination, and the vertical speed in case I should get into an area of downdraft in which case I would initiate my remaining ballast.

I descended from 12,000 to below 6,000 feet fully expecting to impact at every 5-foot increment on the altimeter. At 4,300 feet I felt a light bump or swing as if I had brushed a tree or gone through a wind shear, and shortly after, about 100 feet lower, I saw the vertical speed decreasing. It was passing through 750 fpm when I hit with a good solid impact. The capsule rocked up as if it were on a slope, and then back; I knew I was down and blew the squib. The noise of the squib punctuated the beginning of a very loud silence. The gauges were dead, the altimeter and vertical speed were stopped and I was through. Then I got a flash - I might just be starting, as I counted on no one reaching me until morning. I would get out, take off the helmet, put on the 2-clo suit, build a fire, eat something, and build a small shelter with my parachute. Then I heard the helicopter and flashed the Grimes light around the portholes. I hoped that if I was in the mountains the helicopter would not have an accident landing. Then I got a strange compulsion - if they landed to retrieve me now, I wanted to be outside, to descend the last 6 feet under my own power. I got

the pliers and dikes and cut away all wires but the photo-flash wires, unhooked all my connections and blew the upper Marman clamp. Upon shoving the top off I met Dr. Ruff, Lee Lewis and Don Foster. I had to insist that I be allowed to jump down, and upon doing so found that this jolt made my knees shake and gave a light pain in my stomach. In fact for a couple of minutes I fought the urge to lean or rest on anyone or anything. It was a complete relief to remove my helmet and only then did I get a chance to feel how hot I really was. The cool night air provided a tremendous comparison to the air I had felt for the last few hours.

CHAPTER VI

PHYSIOLOGICAL ASPECTS OF MANHIGH III*

Because of such factors as high capsule air temperature and a non-ventilated partial-pressure suit, this flight was from the human factors aspect an extremely strenuous stress test for the pilot. The physiological data recorded adds in great measure to our knowledge of body function under space equivalent conditions and closely approaches the upper limit of human endurance to stress of this nature.

The simulated flight performed in the WADC low-pressure chamber gave us baseline type impressions for all physiological and related data which were invaluable in decision making during the hot flight. Most interesting and of greatest value was the noting of a labile pulse rate. Variations between rates of 53 to 115 were common with a high of 180 beats per minute observed during a planned rapid decompression of the capsule.

Also worthy of note during the chamber test was the extreme eagerness displayed by the subject for the entire 32-hour run with the obvious intent of doing a good job and making a good impression on the people conducting the test. At this time Lt McClure was the alternate pilot for the flight. This desire to always make a good impression was still evident during the latter stages of the hot flight. In the pilot's report (Chapter V) he states "I became concerned lest this (his weakened condition) be more evident on the ground and each time I answered the ground queries I put everything I had into my voice to keep it apparently sharp and ready".

Data discussed in this section are best understood by considering events in chronological order beginning with subject preparation preflight.

Three days preflight the pilot was put on the low residue diet described in Chapter XI, Nutrition of the Pilot. The reasoning behind this low residue diet is discussed later.

At approximately 1300 hours on each day preceding an expected launch day, the pilot was sedated and put to bed isolated from any distractions. The long preparation time preflight plus the anticipated long flight duration make a well-rested pilot a necessity.

* By Captain E. L. Beeding, Jr.

Lt McClure was awakened at 2030 and given time for a home-cooked meal and to shower and shave. At this stage every effort was being made to insure a relaxed, physically fit pilot at launch time. As the preparations progress, this relaxed state can be maintained only by encompassing the pilot in an orderly, efficient operation.

After arriving at the preparation area the pilot took a sodium phosphate-biophosphate enema as a last minute precaution against any in-flight defecation necessity.

A digression is in order here to discuss the inadequacies of the partial-pressure suits in common usage in the Air Force when they are worn continuously for more than 24 hours. Although no difficulty was encountered on the shortened MANHIGH III flight, during 32-hour chamber runs the urge to defecate has presented a problem. With no access out of this suit the pilot feels a natural reluctance to relieve himself. This means that for some hours he must consciously fight this urge, and what begins as a minor irritation ends as a major problem.

A deficiency which does apply to this flight is the lack of suit ventilation. At the beginning of this program, a contract was written for partial-pressure suits to be specially fitted to potential pilots with provisions for ventilation and a built-in zipper to permit defecation. This ventilation port permitted a low power blower to circulate air around the subject's torso underneath the suit. This provision would have been of great value to the pilot as a cooling mechanism. Once his suit became perspiration-soaked, and with no air flow around the bladders, skin cooling came to an end. As can be noted from the chapter on Pilot Selection, Lt McClure was the sixth candidate for the MANHIGH III pilot. A lack of time prevented the securing of one of these special suits for him.

The author wishes at this point to insert the very firm opinion that for flights of 36 hours or longer no type of partial-pressure suit should be worn. The day must come when the pressurization capabilities of the vehicle have to be trusted. For long duration flights the disadvantages to the pilot outweigh the potential advantages. To invest so much time and money in a vehicle and then to have so little faith in its capabilities that a partial-pressure suit must be worn is incompatible.

A brief preflight physical examination produced the following information: blood pressure sitting - 128/78, standing - 128/82, prone - 120/64; pulse - 76 beats/minute; respiration - 23 per minute; temperature - normal; weight - 174.0.

Putting on the physiological sensors and dressing in the partial-pressure suit was begun at 2230 hours. This operation was completed at 0030 hours the morning of the flight. This phase is time consuming because of the great care with which each step must be done. The EKG electrodes must be properly located, covered, and attached so that they will not dry out or shift position. Further, any item put on the pilot must be properly fitted to produce minimum irritation. A chance crease in the helmet neck seal may be only annoying initially, but after 10 to 15 hours, and after fatigue has set in, these annoyances can become a maddening distraction.

Thermal ribbons were taped to the instep of the right foot and to the inside of the right thigh for skin temperature recording. A plastic encased probe was inserted in the rectum for internal temperature recording. EKG electrodes were located on the right ankle, over the apex of the heart and just under the right scapula corresponding to a non-standard trans-thoracic lead. To prevent drying of the electrode paste during the flight, the electrode face was grooved so as to provide a reservoir of paste and a small sponge was attached to the back of the electrode and moistened with water. After preparing the skin with paste the electrodes were first attached to the body with a waterproof tape which was in turn covered with strips of adhesive plastic tape. Finally both trunk electrodes were held down by Ace bandage wrapped around the chest. This procedure keeps the electrodes moist for 34 hours, in place and the configuration is not irritating to the pilot. GSR readings were taken between a dry cloth electrode on the right instep and a ground lead on the left ankle.

The wiring from each sensor was led out of the partial-pressure suit by the shortest possible route to a conduit running beside the capstan up the leg and trunk.

The respiration sensor, a pressure sensitive carbon mike, was belted to the subject over the partial-pressure suit. Its location was on the front right side of the trunk at the lower edge of the rib cage so as to record its movements during the breathing cycle. After the pilot was completely dressed, the capstans and bladders were inflated to check the suit fit. The sensor outputs were checked with an oscilloscope and adjusted.

At 0037 hours the pilot began situating himself in the capsule. Thirty minutes was consumed loading auxiliary equipment which cannot be installed until the pilot is seated.

Composition of the capsule atmosphere and the method used to obtain this composition was the result of experience gained on the

two previous MANHIGH flights and from several chamber tests. This method of establishment insured (1) check of the capsule seal for leaks, (2) denitrogenation of the pilot, and (3) a physiologically adequate atmosphere for the pilot at altitude.

After the upper and lower capsule halves had been sealed, the only connection between capsule and ambient atmosphere was through a specially built Firewel oxygen regulator. The pilot can manually seal off this connection.

Considering the altitude at Holloman Air Force Base as 4000 feet, our calculations began with a total pressure of 656 mm of hg. The procedures are shown step by step as follows:

1. The capsule was flushed with O_2 from an external source until the pilot gets a reading of 500 mm hg partial pressure O_2 on the capsule Beckman O_2 analyzer. The mixture was then 500 mm O_2 + 156 mm N_2 = 656 mm.

2. After the pilot had closed the Firewel vent, thus blocking any gas exchange with the outside, helium was introduced from an external source until a pressure differential of 5 psi between inside and outside was reached. Then the mixture was 500 mm O_2 + 156 mm N_2 + 250 mm He = 906 mm. As a check for a proper seal of the capsule halves the differential was left at 5 psi for 20 minutes. The attached gauges are watched for any drop in pressure.

3. Since the psi did not drop, the pilot then opened the Firewel vent allowing the mixture of gases noted in 2 above, to escape to the outside until capsule and ambient pressures are equal. Allowing for subject consumption during the 20 minute check period the mixture then was 358 mm O_2 + 114 mm N_2 + 184 mm He = 656 mm. The N_2 content had been considerably reduced.

4. The procedure noted in 3 above is repeated. Firewel vent closed, introduce He until 5 psi is reached, thus adding 250 mm He to the mixture noted in 3 above. Then the Firewel vent was opened, the pressure equalized, and we had 260 mm O_2 + 314 mm He + 82 mm N_2 = 656 mm. Again the N_2 content had been lowered.

5. Again using external oxygen the capsule was flushed with O_2 until the pilot reads 415 mm O_2 P. P. on the Beckman analyzer.

The rest of the mixture is composed of 191 mm He and 50 mm N_2. The pilot breathed this mixture for four hours prior to launch. This serves as the denitrogenation period.

6. As the capsule ascended, the capsule atmosphere bled off into the lower ambient pressure until the regulator seals off automatically at 26,000 feet. The final mixture was 170 mm O_2 + 79 mm He + 20 mm N_2 = 269 mm.

As can be seen in Figure 49, the increased cabin air temperature caused a lowering of the O_2 partial pressure. This was overcome by the pilots introducing O_2 directly from the oxygen system through a constant flow valve.

It can be noted that if one is considering the stresses imposed on the pilot timewise, the launch time is an unrealistic point at which to begin this consideration. By launch time the pilot had already been sealed in the capsule for five hours. From the time he was sealed in and got his gear properly stowed, the pilot had little to do except think, "Are we really going to make it this time? Will the surface winds stay within pre-established limits? Don't let the balloon tear during inflation". The actual launch probably came as a relief.

The data presented in the remainder of this section are in the main the result of exposing a man with a reduced fluid reserve, clothed in an unventilated partial-pressure suit to a capsule air temperature which reached and stayed at 96° to 97°F for several hours.

From launch until approximately 1300 all information received indicated that although in an excited state, the pilot was in good condition. Unfortunately it was during the period in which the command personnel were transferring from the van to the C-47 that the pilot's condition began to deteriorate. The reader, may, at this point, have the impression that the situation deteriorated rapidly. This was not the case. Three methods of measuring the capsule air temperature were available: (1) pilot's report from a gauge on the instrument panel, (2) telemetered, and (3) from a manually operated dry bulb thermometer. The latter was not to be used routinely. See Figure 50 for a plot of all capsule air temperature data.

The panel gauge began to give what was assumed to be erroneous reading early in the flight. By 1200 hours the needle was against the peg at +120°F. Postflight the discovery was made that the sensing element for this gauge had been inadvertently laid on top of the air regeneration unit, the hottest item in the capsule.

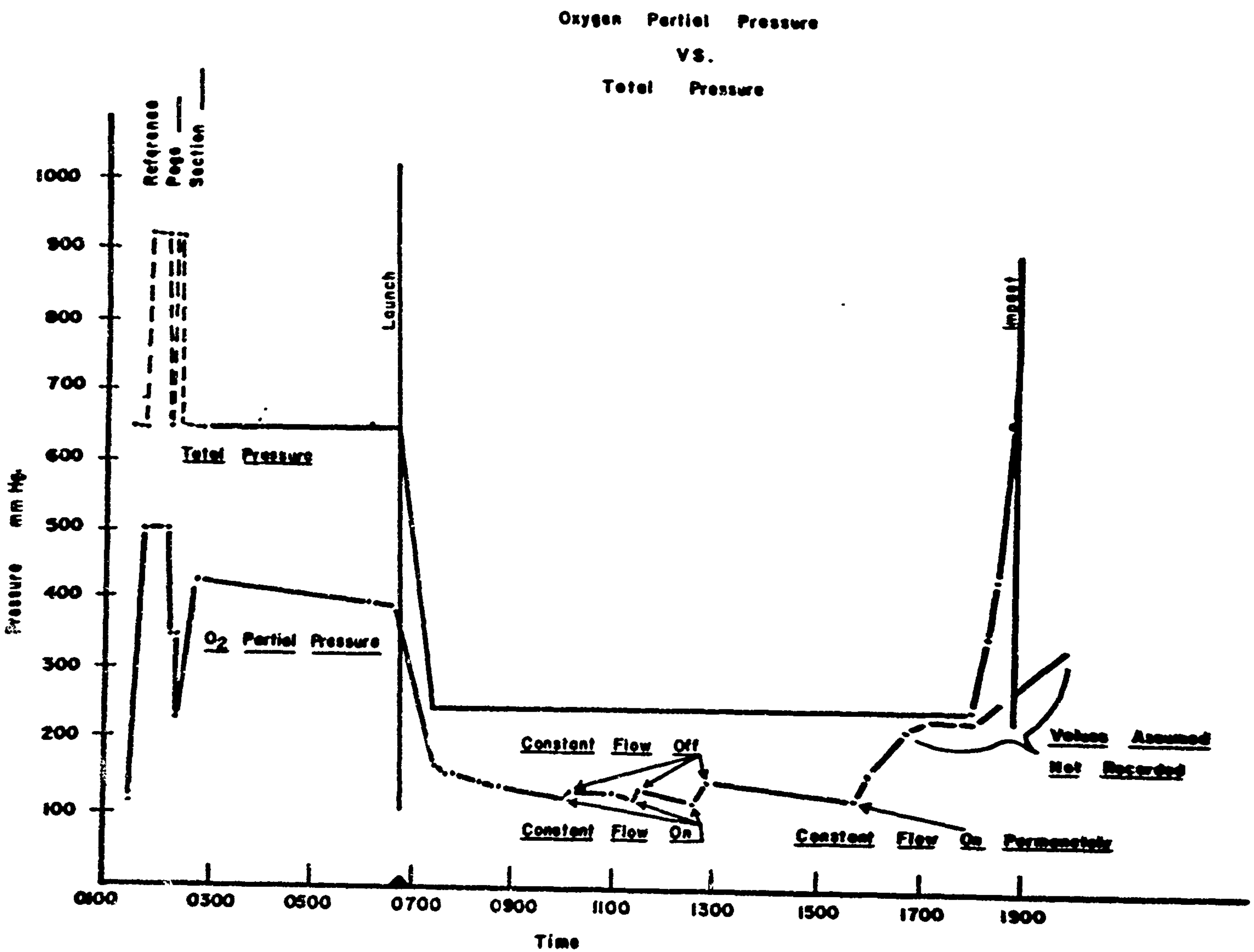


Figure 49. Oxygen Partial Pressure Versus Total Pressure

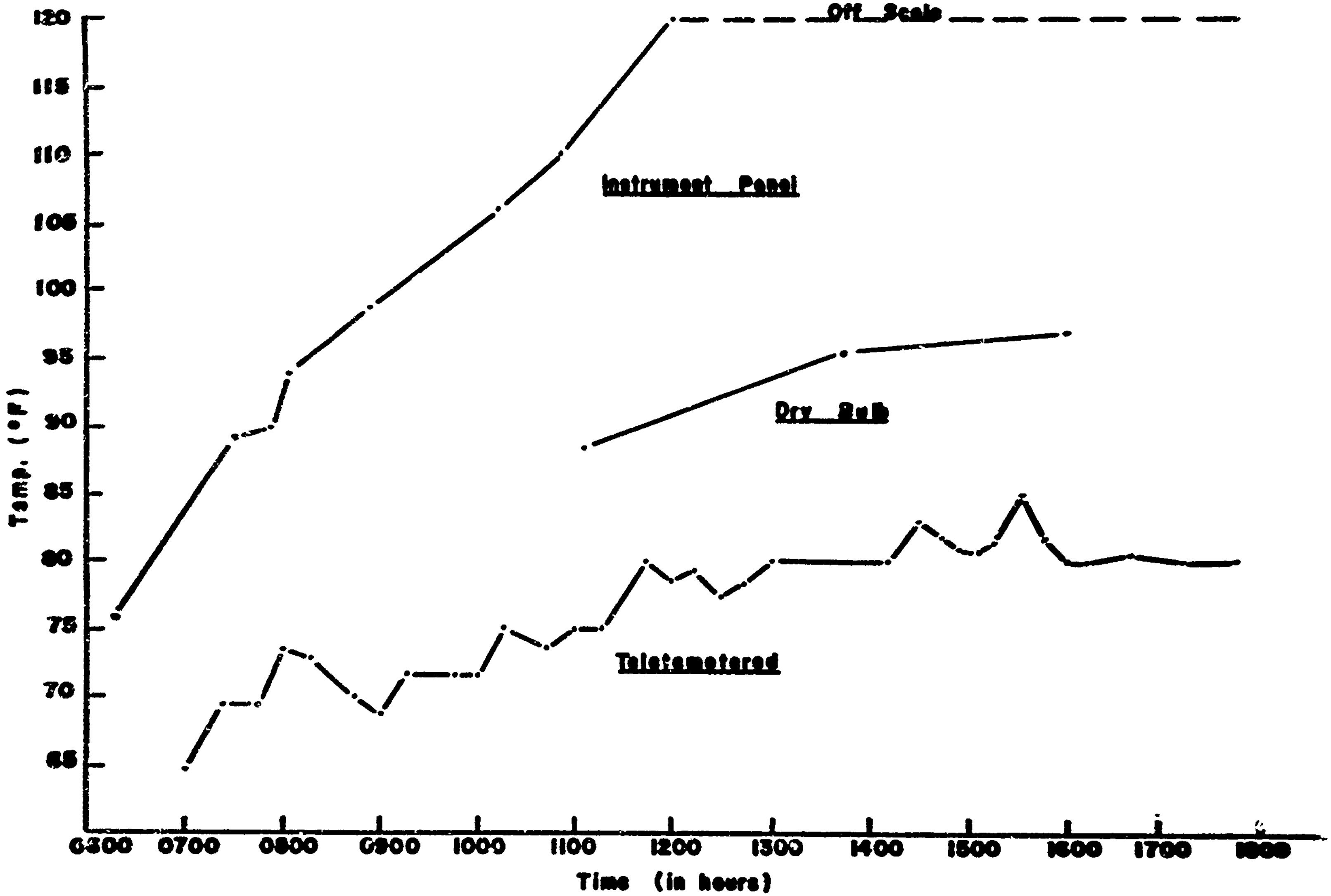


Figure 50. Temperature Data of MANHIGH III Flight

This obviously erroneous reading caused us to place our faith in the telemetered temperature data which seemed to be stabilizing around 80°F. Unfortunately, this too was erroneous.

Finally, Lt McClure's report of excessive sweating led us to doubt the telemetered temperature. A dry bulb reading was taken and we were in trouble with an air temperature of 96°F. Worthy of note before going into a detailed analysis of the data is the fact that activities were scheduled for the pilot to keep him busy constantly. In practice this turned out to be about 70 minutes of work for every hour. As a consequence such normal, but unscheduled, activities as drinking were forgotten and no fluids were taken from 0200 hours to 1300 hours. This is the best example of one of the most important lessons learned on this flight. Those connected with the flight were in the habit of subconsciously considering flight activities in the context of everyday living. Normal ground or aircraft activities are not necessarily good guides for this type of endeavor. That man will eat and drink when he feels the need is a well-known fact. No one even considered that the pilot's workload, his personal interest in this workload, and the overall excitement generated by the flight would cause him to forget such a vital activity as drinking.

At 1400 hours the situation was as follows: partial-pressure suit completely soaked with perspiration, heart rate fluctuating between 140 to 160 and rectal temperature up to 101.5°F. Apparently the combination of high capsule temperature and the soaked partial-pressure suit preventing skin cooling had become too much for the body to combat and Lt McClure was headed for heat exhaustion unless his environment could be changed. The only way this change could be made within a reasonable length of time was to terminate the flight. The decision was then made.

At approximately 1500 hours the subject was judged to be in a condition approaching exhaustion and collapse and the decision was made to drastically limit his activities. Consequently the subject was required to report only rectal temperature, altitude, and descent rate. He was also instructed to drink as much water as possible. All other data recorded after 1500 hours were telemetered.

The last radio communication between the C-47 and the capsule at 1710 gave us this picture: altitude 59,000 feet, a descent rate of 400 feet per minute, capsule temperature 96°F, rectal temperature 106.5°F and a heart rate of 180 per minute. Approximately an hour and a half still to go until landing.

One of the reasons for this loss of communications serves to illustrate the pilot's condition. As a safety measure, the pilot was instructed to remove the spot photometer, an instrument weighing seven pounds, from its location in front of him and to place it on the floor. After getting it loose from its mooring he was too weak to hold the instrument and it fell on the radio foot switch.

Data on physiological condition and on factors effecting the physiological picture were gathered through three media - telemetry, radio voice communication and film from automatic cameras (Fig. 47). Thus the first two were our sources of information during the flight.

Telemetered physiological and related data included time, respiration rate, EKG, BSR, cabin air temperature, and cabin altitude. These were recorded both on tape and on paper, the latter affording a source of immediate read out.

Information routinely reported by radio included pressure differential between cabin and ambient atmosphere, cabin altitude, oxygen partial pressure, carbon dioxide percentage, relative humidity in the cabin atmosphere, capsule air temperature, a subjective opinion by the pilot of his personal condition, pilot's skin and rectal temperatures, and inside capsule skin temperatures.

One can readily see that great gaps in information would result from loss of radio communications. That is precisely what happened on this flight. As is mentioned later in this section, sufficient information was available from telemetry to show that the pilot was near collapse. After the radio failure we in the command post were in the position of the foot soldier fighting from a trench suddenly called upon to direct the entire battle. Only a portion of the facts were available, but decisions had to be made. Other difficulties could have arisen without the knowledge of the command post which would have dictated the use of the large cargo parachute as a quicker means of bringing the capsule to the ground.

As examples of the essentiality of having all information telemetered, consider the following possibilities. Had the air regeneration system failed, the CO_2 percentage build-up would have occurred without our being aware of it. This and the oxygen partial pressure sensor system strikingly illustrate the need for complete automation that will permit telemetry. Using a standard Beckman analyzer the pilot takes the reading indicated by a spot of light on the scale. This light burns only during

the time a button is depressed by the pilot. In hopes of having a complete record postflight the pilot was instructed to line up a sliding metal marker with the light spot location following each reading, thus giving the automatic cameras a target. The author and other pilot candidates found that this lining up of the metal slide after each reading is routinely forgotten when the pilot is fatigued or immersed in other activities. Therefore, Lt McClure was cautioned many times about this requirement but to no avail. Consequently after the loss of communications only one reading is available for O_2 partial pressures.

The dangers inherent in combining radio communications with readings taken by the pilot are many. The chance for human error is present at both ends of the line, gauges are misread and when reported the error can be magnified by incorrect recording.

Sensors which are not automatic open up another avenue for error. The pilot had been reporting a CO_2 concentration in the capsule of 0.0 percent. Suddenly he reported a percentage of 0.8 percent. Not a dangerous level but perhaps indicative of a trend and the first sign of air regeneration system failure. The author and pilot went through a step by step check of the procedure used to get this reading. The pilot had left a plunger in the up position that should have been down. This simple error, although easily found and corrected, disturbed the pilot and ground crew and wasted valuable time.

Experience from this flight shows that the need for telemetry from automatic physiological and related sensors cannot be overstressed. Automation and telemetry offer the best source of complete data and the best chance of obtaining data free from error.

Judging from the information available to us our pilot was probably on the verge of collapse from heat exhaustion. Rectal temperature was 106.5°F. A considerable loss of sodium chloride in his perspiration had to be assumed. Pulse rate was steady at 180 per minute which is the borderline for cardiac decompensation.

This speeding up or shortening of the cardiac cycle at the expense of the diastolic (rest and filling) phase and the period of ejection is energy wise a wasteful process. Although the absence of a blood pressure measuring device made a definitive analysis impossible, it is not unreasonable to assume that the reduced stroke volume output due to the high rate and consequent incomplete filling of the ventricles plus the dilation of peripheral blood vessels as a reflex attempt to cool the skin would reduce his blood pressure to a point bordering on circulatory collapse.

The belief that the pilot's blood pressure was lowered was reinforced by the reporting of visual "apparitions" by the pilot. Just prior to the onset of these visual phenomena, Lt McClure had gone through the tiring procedure required to use one of the urine bottles. This includes getting into a half standing position and remaining there for several minutes. This endeavor was followed by the spot photometer episode. After dropping the photometer, now discouraged and exhausted, he closed his eyes and tried to get some rest. He then noticed what he described as "green globs" in his visual field. These were intermittently present for the next twenty minutes, both with eyes closed or open. They did not track eyeball movement. These visual phenomena were probably the result of cerebral ischemia.

In spite of the conditions described above and without any outside advice for the last hour and one-half, Lt McClure was not only able to continue to function but brought his balloon-capsule system in for a perfect landing. This was a truly magnificent performance considering the fact that he had become the subject for one of the most rigorous stress tests ever recorded.

One hour post impact, the pilot was in the hands of the Base Hospital personnel. His blood pressure was 120/70, rectal temperature 101.4°F, pulse 140 and respiration rate 22. The admitting Medical Officer gave a diagnosis of early heat exhaustion. Lt McClure was given 1000 cc of 5 percent glucose with KCL intravenously and sedated with seconal. An hour later he was given another 1000 cc of the same solution.

The next morning he was discharged from the hospital his usual self - high on the tiger index scale.

CHAPTER VII

PSYCHOLOGICAL ASPECTS OF MANHIGH III*

A. GENERAL

Psychiatric aspects of the MANHIGH experiments are of particular importance because behavorial reactions to space flight cannot be thoroughly studied in a ground environment. High altitude balloon flights provide the best means currently available for simulating psychological stress conditions expected during expeditions in space. Information from these experiments can be applied in planning satellite and other advanced missions with less speculation than if one were to begin with laboratory data.

During the MANHIGH III project, therefore, psychiatric studies were included in the selection, ground testing and flight phases. Objectives during the first two phases were to select a candidate qualified for the mission and to establish a baseline for evaluating reactions to the flight itself. Objectives during the third phase were to describe the subject's behavior and to identify features of the mission which appeared psychologically stressful. An attempt was also to be made to measure changes in performance and to determine which conditions of the flight produced such changes.

B. SELECTION PHASE

Six potential subjects received the full battery of procedures devised for psychological screening of candidates for demanding missions. The techniques employed were:

1. Psychiatric Interviews - In most cases two interviews were given by each of two psychiatrists. These were intended to evaluate the subject's personality structure, with emphasis on motivation and emotional stability. Attention was directed to past experiences in order to define methods customarily employed by the subject for solution of life problems and for adaptation to environmental demands.

2. Isolation - Each subject was placed in a dark sound-proof room containing only a bed, toilet and refrigerator. He was asked to remain as long as possible. This procedure provided information on his capacity to adapt to situations containing few features of his usual environment.

* By Captain G. Ruff

3. Wechsler Adult Intelligence Scale - Because of the MANHIGH pilot's responsibility for conducting experiments and operating complex equipment, a high level of intellectual ability was required. This test of intelligence was administered to measure a variety of verbal and performance functions.

4. Minnesota Multiphasic Personality Inventory - This is an objective, paper-and-pencil test which offers a description of personality based on responses to a 566-item questionnaire.

5. Rorschach Polydiognostic Test - By observing the nature of a subject's associations to ten ambiguous ink blots, a psychologist is able to probe relatively deep levels of the personality. Important information on emotional conflicts and defense mechanisms can be obtained by analyzing what is seen and how it is seen.

6. Thematic Aperception Test - The subject is asked to tell stories suggested by a series of pictures. This test yields information about inter-personal relationships on a fairly deep level.

7. Draw-A-Person - In this projective test, the subject is asked to draw male and female human figures. Information is thus given on his body image and feelings about his place in the universe.

8. Sentence-Completion Test - This consists of incomplete sentences which are completed by the subject. His choice of conclusions offers further information on his personality.

All subjects recommended for the MANHIGH experiment showed superior intelligence, motivation and emotional stability. It was also felt that each of them had intellectual and personality resources to meet the specific demands of the mission. Isolation experiences, which varied in this group from 22 to 43 hours, revealed no undue susceptibility to prolonged isolation or confinement.

C. GROUND TEST PHASE

Observations of changes in psychological functions were made during simulated missions in the WADC high altitude chamber. These were supplemented by self-ratings made by each subject for "alertness", "drive", "efficiency", "tension", and "comfort".

A four-point scale was employed for these ratings, so that "alertness", for example, would be rated "1" if subject felt that

he was maximally alert; "2", if at an average state of alertness; "3", if sleepy; and "4", if barely awake.

Data from this ground test are presented only for the subject who subsequently made the flight.

Lt McClure viewed the chamber run as an opportunity to increase his familiarity with the system. He worked at this task conscientiously, maintaining a high level of efficiency throughout his 31.5 hours in the capsule. A drop in drive and alertness at 0500 during the first day and from 2200 of the first day to 0300 of the second day was consistent with his normal diurnal cycle. Improvement in drive, efficiency and tension scores after 0300 on the second day could be attributed to a short period of sleep, plus anticipation of the end of the run. Occasional periods of euphoria during the last 10 hours also arose from the feeling that the mission had been successfully accomplished and was approaching termination.

It was noted throughout the run that Lt McClure's autonomic functions were highly variable. The effort of arranging urine bottles, for example, was sufficient to raise his pulse to 160. This observation subsequently proved important in interpreting the significance of pulse rate changes observed during the flight.

D. FLIGHT PHASE

It was planned that psychiatric observations would be made throughout the flight. Particular emphasis was to be placed on changes in performance capability and emotional status. Since it was not feasible to equip the capsule with psychological test facilities, these assessments were to be made by questioning and testing the subject from the ground. In addition to these scheduled contacts, information was to be gained from psychiatric monitoring of all the subject's communications with ground personnel.

The emergency arising early in the flight prevented systematic evaluation of the subject's status. Psychiatric impressions, therefore, were based on monitoring radio transmissions and discussions with the pilot after the flight, supplemented by his subsequent written report.

Early phases of the flight were uneventful. The subject appeared highly stimulated by the experiences of the launch and ascent. This subsided after the first hour, and was replaced by a businesslike but more relaxed approach to his duties. These were performed in a routine, efficient manner. He was highly alert, and reported new experiences in extensive detail.

During the first psychiatric "interview" the subject reported a feeling of uneasiness at the absence of any "visible means of support". This arose from his inability to look down and see the reassuring presence of an aircraft wing. It was not alleviated by looking toward the balloon, because the act of looking upward prevented the use of horizon and ground as reference points.

As a result of his preoccupation with his duties and observations, the subject neglected to take food or liquid until 1200. At that time, after finding that his water supply was not functioning, signs of mild anxiety were evident. He also seemed to require excessive effort to accomplish simple tasks. This, it was apparent, was caused by overheating of the capsule. In spite of these difficulties, however, the subject's problem-solving ability and other higher intellectual capacities were unimpaired.

Instructions to descend were received with respectful protests. Although uncomfortable, the subject was convinced he could continue. By 1400, rectal temperature had risen past 103°, and pulse to 150. Activities required increasing exertion. Time seemed to slow down and a feeling of depersonalization was noted.

Along with mounting evidence of exhaustion, the subject showed increased seriousness. By now he had ceased questioning the necessity for terminating the flight and had begun thinking through all phases of the descent. Although unable to escape the sensations of pounding in the head, ringing of the ears and flashing lights before his eyes, his preparations and calculations were highly effective. Each eventuality was considered and appropriate plans worked out. Even though cut off from contact with the ground, his descent rate was accurately controlled.

Severe anxiety appeared only after passage through a haze layer led him to believe that he had passed below the level of the mountains. This passed almost immediately as he realized his mistake. The possibility of death was considered with detachment and balanced by his confidence in himself and the balloon system.

After landing, the subject felt a "compulsion" to open the capsule and descend the final six feet without assistance. Once he had reached the ground, he struggled against the urge to lean on anything. He then consented to return to the base only after he had regained possession of the dictating machine he had employed for recording his thoughts and observations.

Upon reaching the hospital, the subject's apparently good physical condition made it possible to check his weight and obtain an electrocardiogram. He cooperated in these procedures and effectively directed the removal and disposition of his equipment. It was apparent that his state of consciousness was clear. No impairment of memory or other intellectual functions could be noted.

In conclusion, it can be stated that this subject's capacity to withstand stress was unusually high. Even though body temperature, pulse and respiratory measures indicated that extreme tolerance limits had been reached, a high level of intellectual efficiency was maintained. In spite of conditions which might be expected to produce effective changes, no adverse emotional reactions were noted.

CHAPTER VIII

PILOT'S COMPARISON BETWEEN CONFINEMENT TEST, CHAMBER TEST AND ACTUAL FLIGHT*

A. GENERAL

There were a number of differences between the 24-hour confinement test, the 32-hour Wright Field Chamber Test, and the MANHIGH III flight, which can be broken down into two categories, the physic and the physical differences.

The first of the series, the confinement test, was performed within a metal can 3 feet in diameter and 6-1/2 feet tall. Available were a single chair, food and water, and a series of three different gauges to monitor. All contact with the outside was removed except through the communications link installed. The period of time was exactly 24 hours from start to finish of sealed condition. The subject wore a standard Air Force partial-pressure suit.

The Wright Field Chamber Test was simulated flight accomplished by including the pilot in-capsule within the large experimental test chamber and depressurizing the chamber to approach the flight profile. In general, the same preparations are needed as for the actual flight, including capsule preparation, communications, pressurization, prebreathing, etc.

The flight to altitude was started after precooling the chamber to the stratospheric temperature of -55°C, and was accomplished in about 2 hours from start of ascent to the attainment of the 100,000-foot pressure altitude. This pressure altitude was maintained and the flight activity schedule, including pilot reports and hypothetical emergencies, was simulated for 24 hours. Then a descent lasting approximately 3 hours was made.

In the actual flight the preparations were almost exactly the same as for the chamber test, with the exception that the prebreathing period was shortened. The climb to altitude took 3 hours 45 minutes. The system remained at altitude for 3 hours 15 minutes, and a descent was then initiated which took approximately 6 hours.

* By Lt C. M. McClure

B. THE CONFINEMENT TEST

This test began as a novelty. The idea was new, the pressure suit was new, and I feel this newness carried me through the "game" of the first six or seven hours of the test. During this time I was mentally oriented to outdo the outside, which was competing with me to maintain control of the gauges I was facing. The gauges were three different displays of information that could be controlled by myself and also by the project personnel. One was a continuous scale with a needle pointer on it. The needle was to be kept centered on the value "6" on the scale. If moved off this value I was to move it back. Another gauge was a small neon lamp that glowed when activated by the project personnel. The subject's reaction was to press a button which extinguished the lamp. The other gauge was an oxygen flow blinker with a set rate of 12 times per minute. The rate could be varied and was to be corrected by the project people when notified by the subject that he had noticed a changed rate. The time for correction was logged on all gauges as data for the test.

The newness of the situation and the game with the gauges soon wore off and after this interval the suit became a problem. The suit was not fitted to me, but was of approximately correct size. It was an MC-3 partial-pressure suit, but had seen its better days. The helmet was warped and would not sit squarely upon my head and the suit had been repaired in several places.

I had two pressure points, one on the head just above the left eye, the other on the left knee. After about 14 hours the pressure points became numb and no longer were a big problem, and the routine settled down to just another job. The sleepiest time that I encountered was about 1500 to 1630 hours the afternoon of the first day. I did not request to go to sleep during this time; however, the reaction times to the gauges rose to their highest values during this time.

I might add that my own opinion, adopted before this confinement test and lasting throughout the MANHIGH III program, was that if at any time, a test became effective enough to make my performance, upon exit, less than that required for the balloon landing at the end of the actual flight, I would voluntarily excuse myself from the program. I felt that this condition would be realized by myself even before the project people would notice it.

I requested sleep early in the morning hours of the second day because I felt that projecting myself beyond this point without

sleep might cause me to be unable to stay awake near exit time. This, in particular, as I stated above, I did not want to happen.

During the last hours of the test the gauges became somewhat of a diversion from monotony. I ate more in snacks now instead of definite meals. There was a definite need for more diversion from monotony.

During the test I felt a single twinge of resentment toward one of the operators. During the last few hours of operation this individual seemed to adopt a joking or kidding attitude toward the test. I did not appreciate such an approach by the persons outside.

The seat became uncomfortable after about five or six hours, and from then on there was considerable repositioning on it. I did not become particularly tired or feel the need to stretch or to stand up, but I noticed that the seat was uncomfortable.

The suit discomforts during the run were only the two pressure points discussed. The pressure point above the left eye left a large contusion. The discomfort from this remained for approximately two days. The pressure point on the left knee caused a slight limp for the day following the test. Another discomfort that evidenced itself following this test was an itch. This itch was noticed the day after the test and lasted for about six or seven days total. The condition was present on most of the body except the head, but was more severe on the back and chest. Heat aggravated this condition and upon stepping from an air conditioned building into the summer air, the discomfort was especially evident.

C. THE WRIGHT FIELD CHAMBER RUN

In the chamber run no diversion was consciously found to be necessary, even though the time of the test was longer than either the confinement test or the real flight.

It was during this chamber test that I experienced both being slightly too warm, before starting and during the first part of the test, and being cold, during the cooling phase before starting to altitude.

A certain point noted during the cooling phase should be brought out here, as it bears more relation to the difficulty with heat encountered on the real flight than it might have if the flight temperature had been as expected. As the chamber was

cooled and came very close to the equilibrium temperature desired, I felt a chill which caused me to utilize the 2-clo suit. When the pressure was reduced outside and the cabin altitude climbed to and sealed off between 24,000 and 26,000 feet, almost immediately I felt warmer, and noted this feeling both on my notes and over the intercom. This warm feeling occurred when I was still in the same condition of being wet with sweat and with the same inside temperature reading. I decided the reason was the fact that convective transfer of heat from my body was lowered when the inside capsule pressure was lowered. There was no discomfort at all experienced from sitting and being so physically restricted from movement for so long. My pressure suit fit me better and the web seat installed in the capsule was exceptionally comfortable. As compared to the confinement test, the only increased inconvenience came with use of the urine bottles, since I could neither sit nor stand completely, but could only half-crouch.

I feel that discomfort might have been noticed more with this pressure suit had I not been introduced to these by wearing such an ill-fitting suit as I did in the confinement test.

In the chamber flight no pressure point ever reached the condition of being foremost in my mind as the two did in the confinement test. In that test those two points occupied much conscious thought for several hours.

My mental attitude had the advantage of being conditioned both by the confinement test and by my realization that if the primary subject were to be lost to the program, there would be another unprogrammed step-up in tempo to qualify another subject for the flight. Since this second subject would be myself, I tried to push as hard as I could during these tests to learn as much about the systems as possible, always as if I were going to make the flight. This attitude supplied uses for my time during the chamber run that allowed very little time or need to look purposely for diversions.

D. MANHIGH III FLIGHT

The flight had by far enough activity to be anything but boring. In fact, the work schedule was almost impossible to accomplish. I experienced no apprehension during the flight, or before; in fact, it was an extreme pleasure to be launched after so much delay. Other than the heat, no physical discomfort was found during the normal part of the flight. However, during the last one and one-half hours of descent, when the capsule floor was being used to stow loose items in anticipation of impact, the muscles in the lower part of my thigh became cramped.

I think this cramp and pain was precipitated by my having to reposition my feet on top of the items on the floor, lifting my legs off the web seat, and increasing the seat pressure felt by my buttocks. This small change in position caused this discomfort.

Never was any feeling of resentment or anger felt by myself toward any member of the project on the ground. During the trying period of the descent I could easily guess that certain discussions were going on among the project group. I knew that these discussions were spared me out of consideration for my position, especially since there was no real need for me to contribute to them. I had my own definite opinions as to the plan that should be followed; however, I knew that all persons involved had my best interest at heart, and I never felt any animosity because of a difference of opinion.

That the flight aspects were interesting and absorbing to me in the extreme was evidenced in many ways. One of the most outstanding examples is the fact that I grossly over extended myself in neglecting both food and water intake. When I recalled this fact, I suddenly realized my great hunger and thirst, but I was never conscious of approaching these conditions.

E. SUMMARY

The confinement test tested claustrophobia well. However, for me, it was simply a test of long duration in a small place with little diversion. Even though the gauges were monitored during the whole time, they did not provide enough diversion to prevent monotony.

The chamber run was more strenuous than the confinement test, and longer in duration than either that test or the flight. No test was as interesting or as stressing as the actual flight. However, it was so enjoyable that the heat stress condition itself as well as some necessary functions became so relatively unimportant as to be ignored or overlooked. No diversions were necessary; in fact, I cannot believe that boredom could occur on such a flight even if only a few basic scientific instruments were available. Except for being tired and needing liquids immediately after the flight, no difficulties remained. The lack of a good in-capsule voice recorder was noted on both the chamber test and the real flight. Notes had to be taken in the chamber run in place of this recorder. Note-taking is more time consuming, and for this and other reasons, may not allow the true subjective feelings to be obtained for later analysis. The radio failure which occurred during the psychologically interesting

landing phase of the real flight left only the dictet and the subject's memory for recording subjective data. The dictet did not operate properly and all these items of interest had to be recalled from the fallible memory.

During the real flight, from the time the temperature rose above about 90°F, and when my activity dropped low enough to allow time for reflective thinking, I noticed something that had been first noticed in the Wright Field test - the greater retention of body heat when under reduced pressure conditions. This fact would not have been as evident to me personally at these higher temperatures if notice of it had not occurred at constant temperature during the chamber run.

As further evidence during the flight, the command radio heated up to a temperature far in excess of that which would normally have been the heating situation within the radio. However, the radio became almost too hot to touch, while other metallic items within the capsule never approached this condition. Even the walls of the capsule exposed on the sunny side never became this hot. This high temperature condition was a result of the fact that the heat output of the radio itself, combined with the higher capsule atmospheric temperature, could not be transferred away effectively because of the reduced convective ability of the inside atmosphere at its lowered pressure. In order to accomplish this transfer, the temperature rise would have had to be greater than a normal temperature rise.

This same condition of reduced convective transfer ability was undoubtedly operating against my body cooling system, lowering my tolerance to heat and causing a faster rise in my temperature once the body was no longer able to compensate. In substantiating this possibility, I would like to quote from my Wright Field chamber notes.

The conditions were as follows: I was in the capsule, sealed off, with the atmosphere established. The capsule was sealed inside the low pressure environmental chamber at Wright Field. For several hours both the chamber and the inside capsule pressure had been maintained at the local pressure altitude (approximately 800 feet). During this time the refrigeration coils on the chamber walls had been cooled down and the air inside the chamber circulated over them to reduce its temperature to the stratospheric temperature (-55°C). I was sweaty, and as the temperature dropped, I donned the 2-clo suit for warmth. The temperature inside the capsule had stabilized at 57°F when the depressurization of the chamber began. The inside temperature remained constant, but the capsule atmospheric pressure dropped

with the chamber pressure until 25,000 feet was reached. At this point the capsule valve that vented it to the chamber automatically sealed off, leaving the capsule pressure at 25,000 feet for the remainder of the run. The following note was made at this time:

"0947 - Unzipped the 2-clo suit - dry and very comfortable. The warmest that I have felt since the cold runs started. Checked for hypoxia because of the warm feeling. CO_2 okay. PO_2 210 okay. Went on mask for four minutes anyway. Warm feeling proved to be natural retention of body heat."

There was a definite change in body feeling at this point that caused the above questioning approach associated with a constant inside capsule temperature. I can contribute this marked increase in comfort from cold to comfortably cool or warm to reduction of convective transfer within the capsule caused by reduced capsule atmospheric density. I had noticed the condition of "feeling warmer" when only the capsule atmospheric pressure had been changed and the temperature had remained constant. This change in feeling was so definite and rapid as to cause me to consume considerable time making sure this warm feeling was not that accompanying my own peculiar reactions to hypoxia onset. It was so definite as to provide reason enough for me to take steps against hypoxia even though the reading on oxygen partial pressure was available to me.

F. RECOMMENDATIONS

The following recommendations may be made from the results obtained and lessons learned during the MANHIGH III flight and some of the preceding tests:

1. Have in-capsule automatic voice recorder.

2. Use experienced crews on all tests and the flight. Keep the same team if possible.

3. If communications apparently fail, assume the in-flight receiver is still operating. Keep talking and constantly repeating any information that could possibly be of any value to the pilot.

4. Data read-out should be more rapid, even to automatic warning of potential dangers as indicated from transmitted physiological data.

5. Establish the danger areas, such as temperature limits, with the total operation in mind. For instance, in this case the dangerous temperature to which the body can be subjected occur much lower on the thermometric scale than under normal conditions. This fact is true not only because of an excited subject condition and heavy work load, but also because of the physiological effects on the body cooling mechanisms by the pressure suit and lowered capsule atmospheric pressure.

CHAPTER IX

COSMIC RADIATION STUDIES*

A. INTRODUCTION

Since the observation by Chase in 1954 of the greying of hair on mice exposed in the stratosphere for periods of about one day, it was deemed advisable to monitor the arm and chest hair of pilots on the MANHIGH balloon program in order to correlate changes of hair pigmentation with the passage of heavy primary cosmic ray nuclei. This program was initiated on the MANHIGH II flight piloted by Colonel D. G. Simons and similar emulsion preparations were fitted to the prospective pilots for the MANHIGH III flight. This flight was originally planned to take place from Crosby, Minnesota, at geomagnetic latitude 55°N, an area where the low energy heavy primaries can reach undeviated by the earth's magnetic field. Owing to delay in the program, unfavorable flight trajectories during the fall necessitated the transfer of the operation to Holloman Air Force Base, New Mexico, located at geomagnetic latitude 41°N, where the biologically effective low energy primaries are deviated by the magnetic field.

Nevertheless, the skin emulsion monitors were mounted on the arms and chest of Lt C. McClure and processed several days after the flight termination. These particular emulsions developed with an excessively high background of slow electron tracks whose density was such as to render the cosmic ray recording visible only at high magnification, in excess of 500 X diameters. This high electron track background did not originate from flight in the stratosphere, as a ground control plate of identical history showed an identical electron track background. Two other units of emulsion, B and C, described in Table I, mounted on the outside of the gondola developed with a normal background and furnished a measure of the star producing radiation for this flight.

The mysterious blackening of the skin monitor emulsions appears to be explicable on the basis of the following observations. When the balloon launching operation was transferred from Crosby to Holloman Air Force Base, the capsule and all its externally mounted instrumentation (including emulsion blocks B and C) was placed on a C-123 transport plane at a distance of about 15 feet from the cockpit. The skin monitors,

* By Dr. H. Yagoda

TABLE I

DESCRIPTION OF EMULSION BLOCKS MOUNTED EXTERNALLY
ON THE MANHIGH III CAPSULE

Description	Block B	Block C
Components	Ilford G 5 pellicles 600 microns thick	Dual circular castings prepared from Ilford G 5 gel
Age at time of development	62 days	31 days
Volume scanned	0.259 cc	0.138
Star Tally of $\geq$ 3 prongs	96	58
Stars per cc in flown emulsions	370	420
Stars per cc in laboratory control	50	50
Stars per cc due to flight	320	370
Star intensity per cc/day*	895 $\pm$ 91	1030 $\pm$ 135

*Computed on a basis that the balloon spent 8.58 hours at elevations $\geq$ 60,000 feet.

however, were carried in the writer's handbag which was stored during flight near the pilot's cockpit at a distance of about three to five feet from the radium activated luminous dials on the control panel. It would thus appear that these preparations were spoiled as a result of about 18 hours proximity to the numerous radioactive gamma ray emitting sources on the control panel. The lesson learned from this experience should be made known to all personnel concerned with the recovery of emulsion following rocket and satellite exposures. The recovery crews on the Atlas and Discoverer programs have been alerted to keep the emulsion blocks as far as possible from the plane's cockpit and to avoid wearing watches with luminous dials. This information should be made available to similar programs such as the X-15 and the DYNASOAR.

B. SKIN MONITOR PREPARATION

The emulsion units worn by Lt McClure represent an improvement in design over those mounted on Colonel Simons. On the MANHIGH II flight some sweat penetrated the flexible protective housing causing adhesion of about 10 percent of the emulsion surface to the black paper wrapping. This difficulty did not occur on the MANHIGH III flight, despite the excessively high body temperature of the pilot, owing to the incorporation of a layer of polyethylene sheeting between the emulsion and the black paper. This additional waterproofing did not increase the bulk or rigidity of the monitor appreciably, and on post-flight questioning the pilot stated that the units did not cause discomfort or interfere with his operations during the flight. Since these special skin monitoring devices may prove useful on other manned flights near or above the top of the atmosphere, a complete description of their construction follows:

1. Ilford G 5 unsupported emulsion sheets 600 microns thick are cut into rectangular pieces measuring 5 by 10 cm. In order to secure adequate pliability the sheets should be maintained at 60 to 70 percent relative humidity for one to two hours. This does not reduce sensitivity appreciably but permits fitting the final preparation to the contour of the arms and chest.

2. The emulsion is placed with its dull side uppermost between two sheets of thin polyethylene sheeting and covered with sheets of thin light-tight paper. The edges are rendered light-tight by sealing the periphery with a band of 10 mm wide black nylon adhesive tape. The unit is then wrapped in a sheet of water-proof "Parafilm" measuring 11 by 12 cm, overlapping edges and sealing them with cellulose adhesive tape. To prevent tearing

of the thin "Parafilm" material it is covered with a strip of white surgical adhesive plaster 5 by 20 cm. All identification and orientation marks are inscribed on the surgical tape surface.

3. A particularly useful orientation mark is to inscribe a circle 10 mm in diameter near a corner of the preparation. The compass needle should be pressed into the emulsion layer so as to produce a mechanical latent image. The large external circle defines the internal position of this point and is more readily visible on photographs of the preparation mounted on the body. The units for the right and left arm should be identified by an "R" and "L" mark, respectively.

4. The skin monitors should be placed on a relatively flat portion of the arm and oriented so that the edges are defined by characteristic skin pigmentation marks such as A and B of Figure 51. This serves to define the corresponding coordinate of point C with reference to the skin. In the absence of natural pigmentation marks, four tattooed points at the corner of the emulsion can be imprinted with indelible ink.

5. The monitor is then fitted to the arm contour with the aid of three bands of one inch wide adhesive tape. The final tension should be applied by the pilot so as to feel comfortable and not to interfere with circulation of the blood. The rubberized sleeve of the pressure suit worn by the pilot is largely instrumental in keeping the monitor in place. The arms should be photographed before and after flight and the region under and adjoining the monitor should be carefully inspected prior to flight, for the presence of background greying hair.

6. After flight termination and removal of the pressure suit the skin monitor preparations are usually bathed in sweat. After removal they should be blotted between absorbent paper and allowed to air dry before being opened in the darkroom. Prior to development, appropriate identification marks should be inscribed on the emulsion proper. As is well known, pencil inscription marks on the upper emulsion surface make permanent markings on development. The emulsion sheets are mounted on subbed glass and developed by any of the standard methods for 600 micron thick pellicles as practiced in cosmic ray nuclear emulsion research. Since the bright lower surface of the emulsion adheres best to the glass support, care should be taken in preparing and orienting the monitor, that this particular surface is adjacent to the skin.

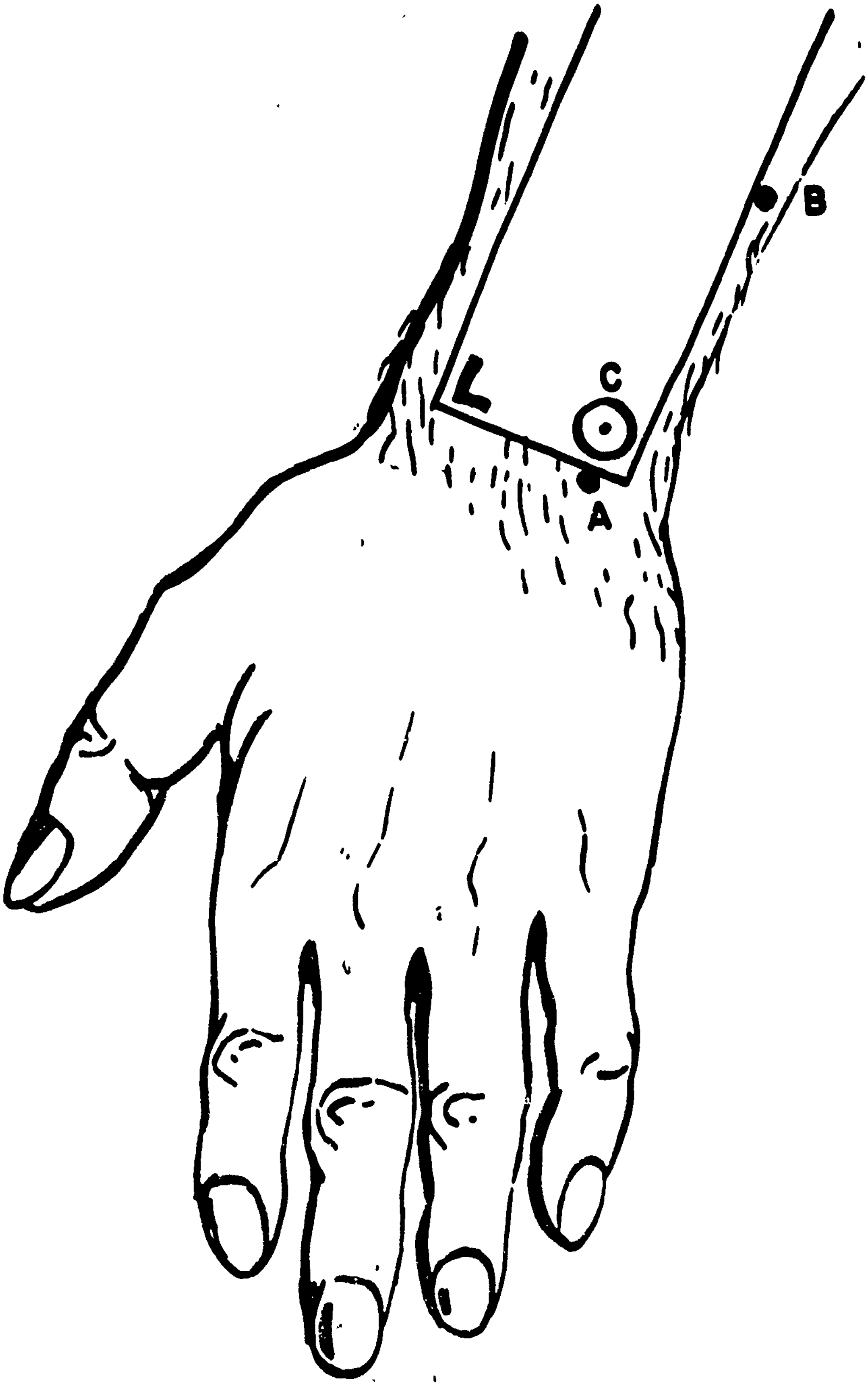


Figure 51. Sketch Showing Orientation of the Monitor with Reference to Natural Skin Pigmentation Marks

7. The processed emulsion is examined microscopically for the characteristic tracks of heavy primaries and the coordinates of the points where the tracks enter and leave the emulsion layer are plotted on graph paper. The distance between the two points represents the horizontal projection of the track and is proportional to the obliquity of the incident heavy particles. The steep tracks are most suited for correlation with changes in hair or skin pigmentation. A typical graph of track orientation is reproduced in Colonel David G. Simons' report "Observations in High-Altitude Sealed-Cabin Balloon Flight" page 83, Volume 10, No. 2 Air University Quarterly Review.

C. EXPOSURE TO STAR PRODUCING RADIATION

Two blocks of nuclear emulsions, described in Table I, were mounted on the outside of the capsule. These developed satisfactorily and star counts of nuclear disintegrations constituted of three or more prongs were tallied along measured swaths of emulsion using a 40 X oil immersion fluorite objective and 10 X eyepieces. The two independent results of 895 ± 91 and 1030 ± 135 stars per cc per day are in good agreement within the limits of statistical error. The average value of the two analyses of 946 ± 76 stars per cc per day is essentially identical with measurements made at Pyote, Texas ($\lambda = 41°N$) on stratosphere balloons launched in 1951 and 1954, which averaged 815 ± 104 stars per cc per day. This suggests that the star producing radiation does not vary markedly with the solar sunspot cycle at 41°N geomagnetic latitude. On the MANHIGH II flight conducted at geomagnetic latitude 55°N a very pronounced time variation was observed. The results of the two piloted flights are compared in Table II.

D. SCINTILLATION OBSERVATIONS

The pilot of MANHIGH III was provided with a zinc sulfide phosphor screen and a 7 X prefocused magnifying glass in an attempt to note the nature of the light emitted by the phosphor as a result of activation by the cosmic radiation. The observations of the scintillations necessitates a dark adapted eye and this program was scheduled for the night hours of the flight. Since the balloon was forced to descend during daylight these visual observations could not be made.

Lt McClure was also provided with a second zinc sulfide screen mounted between two film pack containers in an attempt to record light emission photographically. On one set of films, exposed for two hours, a pair of grey spots developed in perfect register on the opposing films. Microdensitometer tracings of these spots

are exhibited in Figure 52. The blackening may have been produced as a result of the disintegration of a zinc or sulfur nucleus in the phosphor screen, the secondary alpha particles and protons traversing the zinc sulfide grain producing the luminescent reaction.

TABLE II

COMPARATIVE STAR PRODUCTION ON MANHIGH FLIGHTS

Flight Data	MANHIGH II	MANHIGH III
Pilot	Lt Col D. G. Simons	Lt C. M. McClure
Date	19 August 1957	8 October 1958
Launching Area	Crosby, Minnesota	Holloman Air Force Base, New Mexico
Geomagnetic Latitude	55°N	41°N
Maximum Altitude	101,000 feet	99,000 feet
Duration at $\geq$ 60,000 feet	29.2 hours	8.58 hours
Star Intensity per cc per day		
Large emulsion block:	1170 $\pm$ 42	946 $\pm$ 76
Skin monitor:	1435 $\pm$ 54	No reading

E. COLLECTION OF RADIOACTIVE AND METEORITIC DUSTS

During the summer and fall of 1958 a number of settled dust samples were collected at high altitudes during the flight of stratosphere balloons. These samples were tested for radioactive aggregates and nickel-bearing particles by nuclear emulsion and

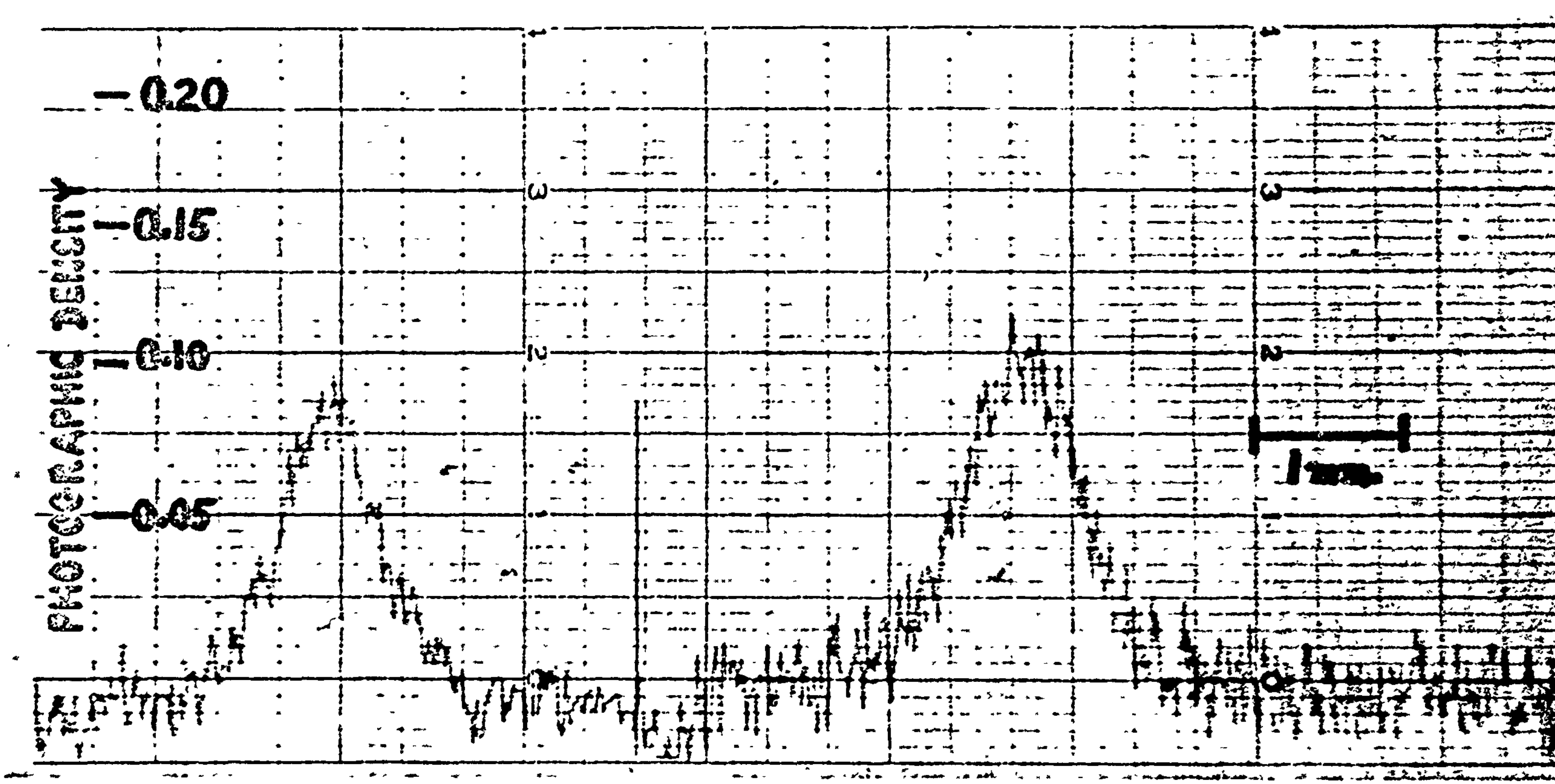


Figure 52. Microdensitometer Tracings During MANHIGH III Flight

microchemical techniques. Advantage was taken of the MANHIGH III flight as an upper atmosphere sampling device. In particular, it was possible to locate the collection dishes on the top-most metal valve plate thereby avoiding the shadow introduced by the body of the balloon. The results of these observations are summarized in Geophysical Research Directorate Laboratory Reports No. 9 and No. 10.

CHAPTER X

ANALYSIS OF PHYSIOLOGICAL AND CABIN TEMPERATURE DATA*

An examination of the temperature data from the MANHIGH III flight shows that heat was stored in the pilot's body to a degree sufficient to cause termination of the flight. The analysis will be made in terms of a non-standard physiological index, because standard indices, as developed at UCLA and the Aero Medical Laboratory, WADC, are based on severe heat exposure for relatively short time periods. In the MANHIGH III flight, the time period was long and the heat load externally was relatively mild. While it would be helpful to be able to use either the UCLA "Body Storage Index" or the "Index of Strain" as used at the Aero Medical Laboratory these indices are meaningless because of the long time involved in the MANHIGH III flight. The "Body Storage Index" is an expression of heat storage at an hourly rate. The "Index of Strain" uses an hourly rate for rise in rectal temperature and an hourly rate for secretion of sweat, which was not measured in the MANHIGH III flight.

The very high level of heart rate and the high rectal temperature mean that the pilot was well into a state of "impending heat stroke" as defined in reports from the Aero Medical Laboratory, WADC.** This state of impending heat stroke is synonymous with the physiological tolerance limit as used in experimental work in severe heat exposure.

Another way to define the physiological end-point is by calculating the total heat stored in the body. When storage has reached 100 kcal/m^2, the critical level has been reached. The calculation of heat storage is made according to the formula shown as equation (1).

* By Dr. Paul Webb

** Veghte, James H. and Paul Webb, "Clothing and Tolerance to Heat", WADC Technical Report 57-759, 1957.

Veghte, James H. and Paul Webb, "Extending Human Tolerance to Heat by Prior Body Cooling", WADC Technical Report 58-412, 1958.

$$q_s = \frac{W_b \times 0.83}{S.A.} \Delta t_b$$

$$= \frac{81.7 \text{ kg} \times .83}{2.04 \text{ m}^2} \; 4.06^\circ \text{ C} \qquad (1)$$

$$= 134 \text{ kcal/m}^2$$

q_s is body storage in kcal/m^2

W_b is body weight in kilograms

S.A. is surface area in m^2

Δt_b is change in mean body temperature

0.83 is a constant to convert body weight into an equivalent weight of water.

Values from the MANHIGH III flight have been substituted into the formula for body storage and a solution of the equation shows that 134 kcal/m^2 were stored over the entire flight. This is obviously above the critical level.

Body storage is based upon a calculation of the change in the mean body temperature. The mean body temperature (t_b) has been computed by using the Burton equation, shown as equation (2).

$$\Delta t_b = 0.67 \Delta t_r + 0.33 \Delta t_s$$

$$= 0.67 \times 4.16^\circ \text{ C} + 0.33 \times 3.9^\circ \text{C} \qquad (2)$$

$$= 4.06^\circ \text{ C}$$

Δt_b is the change in mean body temperature

Δt_r is the change in rectal temperature in degrees C

Δt_s is the change in mean skin temperature in degrees C.

The change of four degrees C in mean body temperature is also quite high.

A prior experiment under laboratory conditions, on the ground, with the same subject, was made at the Aero Medical Laboratory on 30 July 1958. The conditions were quite different from those in the MANHIGH III flight. However, in both exposures a very great heat storage level was reached. In the laboratory experiment the subject was exposed nude to a temperature of 160°F in the experimental chamber at the Aero Medical Laboratory. In 60 minutes the subject had reached the beginning of the state of impending heat stroke, and the experiment was terminated. Calculations from that exposure were made using the same formulas as shown in equations (1) and (2). The change in body temperature was 2.5°C and a total of 83 kcal/m^2 was stored. The terminal heart rate in this experiment was 160. All the values were lower in the laboratory experiment than in the MANHIGH III flight but we purposely stop at the beginning of the state of impending heat stroke, and termination of the experiment is possible immediately after the decision is taken. In contrast, in the actual balloon flight, after the decision was made to terminate the flight, another period of hours was needed to bring the balloon back to earth.

There are some interesting differences in the data for the laboratory experiment and the actual MANHIGH III flight. In the laboratory experiment the terminal rectal temperature was 102.8°F, compared to 106.5° in the flight. However, the measured mean skin temperature reached 102.8° in the laboratory experiment since the external heat load was extremely high - air/wall temperature of 160°F. In the flight, the very high rectal temperature was balanced by what must have been a somewhat lower (although not measured) skin temperature. An assumption has been made that the skin temperature at the end of the MANHIGH III flight was approximately 100°F. A calculation of the mean body temperature in the two experiments shows that in the laboratory experiment t_b = 102.8°F and in the MANHIGH III flight the terminal t_b = 104.3°F.

If the decision to terminate the flight was made on the ground at about 1630, then values can be taken from the data to determine body storage and mean body temperature at this time. The rectal temperature at 1630 was 105°F, and we can assume a mean skin temperature of 99°F. Parenthetically it should be pointed out that these skin temperatures for the flight are pure guesswork, but they are based on experience with somewhat similar exposures in

the laboratory. Calculating the mean body temperature we find t_b = 103°F and body storage was 111 kcal/m^2. At this point the pilot's heart rate had already reached the maximum level of 180. For the next two hours heat storage continued, only to stop when the balloon had landed.

It is not hard to find causes for the excessive heat storage which caused the flight to terminate. First, the subject was, of course, producing metabolic heat, at a level well above basal.* Although his activity level was that of a sitting man, there was the added excitement of the pioneering and potentially dangerous flight. The pilot's normal heat loss was compromised by the unventilated partial-pressure suit which was worn. This suit had rubberized bladders which covered the torso and part of the legs. The pilot can lose heat by radiation, conduction and convection as long as the cabin air and wall temperatures are lower than his surface temperature. As these temperatures approach the surface temperature, and this happened early in the flight - about 0900, then the gradient from surface to cabin diminishes to 0. When the cabin air and wall temperatures go above the pilot's surface temperature, a heat gain results, the magnitude again depending on the gradient from environment to man.

The evaporative pathway is the normal way to lose heat in a warm environment, both the heat from metabolism and the heat gained from the environment. As noted above, evaporation is already limited because parts of the body (40 to 50 percent in a partial-pressure suit) are covered with rubberized bladders. Sweat secreted in these areas cannot cool because it cannot evaporate. However, cooling is proceeding on the rest of the body surface - face, hands, arms, and parts of the legs - where evaporation can take place. This water is taken up by the cabin atmosphere.

The cabin, or gondola in this case, is sealed. Water vapor added by the man must be removed if a dry air is to be maintained. Dry air is vital to the evaporative heat loss process. If cabin air becomes heavily laden with water vapor, then this final means of losing heat is lost. The data tell that soon after 0900, when heat could be lost only by evaporation, this avenue of heat loss also was lost. Heavy sweating probably began between 0900 and 1000 hours. By 1100 the relative humidity was 55 percent and the dry bulb temperature was 93°F. This is equivalent to a water vapor pressure of 22 mmHg - a moist atmosphere. Evaporation from the skin is seriously reduced at this partial pressure of water vapor. As the flight continued even more water vapor was taken

* Best estimate is 100 kcal to 120 kcal/hour. No increase with the high internal temperature.

up by the air, which was gradually heating, and therefore could hold more water vapor. By 1400 the dry bulb temperature was about 99°F, and the relative humidity 52 percent, so that the partial pressure of water vapor was about 25 mmHg. The vapor pressure gradient was very small in a physiological sense. Evaporation of sweat was minimal.

The effect of this high water vapor content in the cabin, plus the restriction to evaporation imposed by the partial-pressure suit, was to virtually eliminate heat loss by evaporation. This means that all the metabolic heat had to be stored instead of dissipated. The curve of rectal temperature showed that this is what happened. Starting at 1100, the internal body temperature began a precipitous and a steady climb, to terminate only at the end of the flight.

The amount of heat stored by this pilot was a good 30 percent above the usual level of 100 kcal/m^2. This is a heat exposure of heroic proportions. That this man was able t, perform even simple flight tasks in the difficult and tense period of landing is a testimony to his determination and ability. The pilot was certainly well selected for his job.

In summary are the following observations:

1. Cabin temperature control was inadequate, and this permitted a gradual temperature rise to above the level of the body temperature.

2. The system for removing water vapor became overloaded, permitting the partial pressure of water vapor in the sealed atmosphere to rise to a high level.

3. The high water vapor pressure, the warm environment, and the rubber bladders in the partial-pressure suit all combined to prevent loss of metabolic heat. This heat continually produced was stored.

4. When sufficient heat had been stored (over 100 kcal/m^2) and the mean body temperature was above 103°F, the state of impending heat stroke had arrived. The high and rising rectal temperature and the high pulse rate are pathognomonic of this state. By surmise, active sweating had diminished, and the pilot was in an anxious, restless and distressing mental state, just short of collapse from full blown clinical heat stroke.

CHAPTER XI

NUTRITION OF THE PILOT*

A. CHAMBER TEST

1. Introduction

The primary goal of this experiment was to study the subject's reactions when placed in an unusual situation, i.e., a setting which lacked most of the features of his accustomed environment. The following data pertain to the subject's reaction to food while alone in the absence of light and sound for an undetermined period of time.

2. Procedure

The subject, Lt Clifton M. McClure, as part of a psychological test program performed by the Stress and Fatigue Section, Bio-Physics Branch, of the Aero Medical Laboratory, WADC, entered a dark, soundproof chamber, 2 September 1958 and came out after an approximate two day stay. This chamber was furnished with a bed, chair, table, refrigerator, and chemical toilet.

Sufficient food for a five day period was provided in advance. Table I lists the inventory of foods, type of packaging, and code used to distinguish one food from another. Some foods were packaged in plastic containers. For these, foods within a similar group were packaged in similar shaped containers. Covers of containers of different foods within a specific group were coded with masking tape. Thus, foods were identified by touch. Other foods which could be recognized by their natural shapes were wrapped, if necessary, in waxed paper or aluminum foil. Prior to the test period, the subject was apprised of the code system and the arrangement and placement of food, both in and out of the refrigerator. Food requiring no refrigeration was systematically arranged on the table. This area was also used for the storage of accessory items such as paper cups, plates, straws and napkins, spoons, can opener, and Wash n Dri packets.

Table II cites the calculated nutritional value of the food as provided and a comparison with recommended daily allowances.

* By Miss B. Finkelstein

TABLE I

DARK - ISOLATION STUDY
FOODS AND METHOD OF PACKAGING

Food	Unit	Amt	Type of Packaging	Code
Beverages				
*Milk	8 oz	4	Carton	
*Toddy	8 oz	4	Can	
Bread				
White	Slices	5	Triangular container	
Candy				
Caramels	Cubes	12	Cellophane	
Chewing gum	Package	1	Original wrapper	
M&M's	2 oz	2	Carton	VV
Peppermints	2 oz	1	Carton	V
Cake and Cookies				
Brownies	1-1/2" x 1-1/2" x 1" squares	6	Wax paper	
*Fruit Cake	5 oz carton	1	Round container	x
*Pound Cake	2 oz carton	1	Round container	xx
Sugar Wafers	6 per package	2	Aluminum foil	
Dairy Products				
*Eggs (Hard Cooked)	1	2	Aluminum foil	
*Cheese, Swiss	2" x 2" x 3/4"	2	Aluminum foil	
Fruit, Fresh or Dried				
*Pears	Medium size	3		
Raisins	1-1/2 oz	2	Carton	
Fruit, Canned				
*Apricots	6 oz	1	Rectangular container	—
*Peaches	6 oz	1	Rectangular container	—
*Pineapple	6 oz	1	Rectangular container	—
Fruit Juice				
*Pineapple	6 oz	2	Can	
*Apple	5-1/2 oz	2	Can	
*Orange	5-1/2 oz	2	Can	
*Tomato	5-1/2 oz	2	Can	

* Foods stored in the refrigerator

TABLE I (Cont'd)

Food	Unit	Amt	Type of Packaging	Code
Meat				
*Beefsteak	6 oz	1	Square container	0
*Chicken	6 oz	1	Square container	00
*Turkey	6 oz	1	Square container	000
Nuts				
Assorted	5 oz	1	Carton	
Sandwiches**				
*Ham	--	4	Rectangular container	
Vegetables				
*Carrot Sticks	1-1/2 oz	2	Aluminum foil	
*Celery Sticks	1-1/2 oz	2	Aluminum foil	

* Foods stored in the refrigerator

** Two sandwiches prepared with white bread; two with rye bread

TABLE II

NUTRITIONAL VALUE OF FOOD PROVIDED FOR DARK - ISOLATION STUDY*

	Calories	Proteins gms	Fat gms	Carbohydrate gms	Calcium mg	Iron mg	Vit A I. U.	Thiamin mcg	Riboflavin mcg	Niacin mg	Ascorbic Acid mg
Food as Provided for 5-day Period	15,000	500	700	1865	4914	93.9	36,045	7,000	14,000	88	384
Food as Provided per Day	3,000	100	140	373	983	18.8	7,209	1,400	2,800	17	77
Recommended** Allowances	3,000	70	-	-	800	12.0	5,000	1,600	1,600	16	75

* Values obtained from Food Values of Portions Commonly Used, 8th Edition, A. DePlanter Bowes and C. F. Church, 1956.

** Recommended Dietary Allowances, Revised 1958. National Academy of Sciences, National Research Council, Publication 589.

3. Results and Discussion

During the 40-1/2 hours the subject remained in isolation he consumed 4,754 calories. When computed on a day's basis, this quantity is equivalent to approximately 2,800 calories, an amount adequate for an individual performing little physical activity.

Much satisfaction was reported with the amount and variety of food. Food was eaten partly in the form of meals, and partly as snacks. An inability to identify white and rye bread used for sandwiches interfered with taste satisfaction and thus the enjoyment of food.

A considerable degree of preoccupation with food was indicated by the opening and closing of the refrigerator door at approximately one hour intervals. This was also illustrated by the remark, "Eating habits really change in here. You never know whether you are eating because you are hungry or because you want something to do".

4. Conclusion

Food, for this test subject, was a means of counteracting the stress of darkness and isolation. It was a method of obtaining personal satisfaction. Despite this psychological tie with food, caloric intake compares favorably with recommended daily allowances for persons engaged in sedentary activity. Frequently, under these circumstances, inordinate amounts of food are consumed.

B. PREFLIGHT DIET

MANHIGH balloon flights require the balloonist to wear a pressure suit assembly. Such protective clothing makes defecation difficult during flight. In order to cope with this problem, a low residue diet was recommended. These recommendations are included as Appendix A.

The low residue diet was adhered to both prior to the Low Pressure Chamber Flight Profile conducted at Wright Air Development Center, 5 to 7 September 1958, and the actual balloon flight of 8 October 1958. In the first instance, the low residue diet was consumed for a 72 hour period; in the second for a 96 hour period because of an aborted mission on 7 October 1958.

There was no need for defecation during either the simulated or actual balloon flight.

C. LOW PRESSURE CHAMBER FLIGHT PROFILE TEST

1. Introduction

The MANHIGH III project includes a preliminary simulated balloon flight. This phase of the project was conducted in the low pressure chambers at Wright Air Development Center. The purpose of the trial was to check the operation of gondola systems and equipment under conditions of time and altitude which were anticipated in flight. At this time, the acceptability and functional utility of foods considered for use were determined.

2. Procedure

A feeding program for the MANHIGH flight was established according to the following criteria:

a. The balloonist will spend a minimum of 24 hours in the air and approximately 48 hours in the capsule.

b. During flight the activity level of the subject will be extremely high and will be accompanied by considerable stress. Yet, maintenance of peak efficiency is necessary.

c. The weight of food should be maintained at the lowest level compatible with good acceptability and adequate nutritional value.

d. The storage space for food and accessory items will be limited.

e. Weight and space limitations preclude the use of any food service equipment.

f. The temperature range of the gondola will be 40 to 75°F. Humidity will average 50 percent. Capsule pressure will approximate 24,000 feet.

Table III presents an inventory of food and amounts provided for the trial test. Accessory items are also included.

Table IV gives the calculated nutritional value of the food as provided.

A considerable period of time was involved in preliminary preparations, donning the pressure suit, prebreathing of oxygen, and closure of the capsule. Hence, many hours elapsed between

TABLE III

SIMULATED MANHIGH III BALLOON FLIGHT
INVENTORY OF FOOD AND ACCESSORY ITEMS

Food	Unit	Amount Provided
Beverages		
*Coffee Drink	8 oz bottle	1
Milk	8 oz can	2
Toddy	8 oz can	2
Candy		
Chewing gum	Package	1
M&M's	2 oz package	1
Cake, Cookies, Crackers		
Chocolate Oreos	Package of 5	1
Pound Cake	1-1/2 oz carton	1
Ritz Crackers	Package of 5	1
Fruit and Fruit Juice		
Raisins	1-1/2 oz carton	1
Orange Juice	5-1/2 oz can	3
Pineapple Juice	6 oz can	3
Meat		
Beef Cubes	3 per package	2
Beefsteak (IF)	3 oz package	1
Beef, Semi-solid	3-1/2 oz tube	2
Chicken, Semi-solid	3-1/2 oz tube	2
Nuts		
Assorted Nuts	5 oz package	1
Accessory Items		
Can Opener		1
Napkins	Individual	6
Straws	Individual	10
Wash n Dri	Packets	6

* A high protein beverage prepared with Sustagen.

TABLE IV

NUTRITIONAL VALUE OF FOOD AS PROVIDED FOR SIMULATED MANHIGH III BALLOON FLIGHT*

	Calories	Protein gms	Fat gms	Carbohydrate gms	Calcium mg	Iron mg	Vit A I. U.	Thiamin mcg	Riboflavin mcg	Niacin mg	Ascorbic Acid mg
Food as Provided for 48-hr Period	4,450	189	216	473	2,212	25.5	3,127	3,261	3,656	32.0	311
Food as Provided Per Day	2,225	94	108	236	1,106	12.8	1,563	1,630	1,828	16.0	155
Recommended** Allowances	3,000	70	-	-	800	12.0	5,000	1,600	1,600	16.0	75

* Values obtained from Food Values of Portions Commonly Used, 8th Edition, A. DePlanter Bowes and C. F. Church, 1956.

** Recommended Dietary Allowances, Revised 1958. National Academy of Sciences, National Research Council, Publication 589.

consumption of the last meal and the onset of the test period. In order to provide the subject with a concentrated form of sustenance, eight ounces of a high protein beverage (coffee drink containing Sustagen*) were made available to him. See Appendix B and C for composition and nutritive value.

3. Results and Discussion

The acceptability and functional utility of the food provided is best illustrated by the subject's report on this phase of the project.

"0915 - 1 beefsteak tube - Initially did not like this method. I think this was due to breaking the old eating habit of solid foods. I must admit my first impression made me think of eating something someone else had chewed. This distaste for the method of food storage disappeared before the tube was finished when I had gotten used to the idea. I was extremely pleased with the final waste product, the rolled-up tube. Space was a critical item both actually and mentally, and the importance of having a small, easily stowed waste container cannot be overemphasized. If it had remained a large item, I would not have been able to store it completely out of the way, and it would have become one of those annoying items to be moved and relocated every time I went for another item.

"Also drank one toddy with this - refreshing but a little heavy. This 'heavy' feeling may well be due to the fact that I seldom drink chocolate.

"Also drank small amount of a coffee drink, perhaps one-third bottle.

"1145 - 1 can pineapple juice
2 chocolate crackers
2 juice cans water - thirsty but didn't want just water. Generally, water was consumed by being transferred into juice can first so as to give some measure of the volume consumed. However, the capsule tube method was used directly some because of the inability to store open juice cans. This can be measured only as total consumption after the water was weighed at the end of the run.

"1428 - Four beef cubes. I think these were enjoyable in the more normal form only because of normal habit, since chewing becomes a task when in the pressure suit. I do believe this task would soon make the luxury of remaining with habit, just to be

* Sustagen produced by Mead, Johnson and Company, Evansville, Ind.

able to chew, undesirable to the crew member and would bring him rapidly to the point of recognizing the value of the tube. This was the case here with me.

"1 can orange juice
1 juice can water
Another one-third bottle coffee drink - normally I do not drink a lot of coffee, although this drink did not seem very strongly coffee, and I drank it mainly for variety.

"One-half tube of chicken - consistency was little thinner than other type tube foods, and I felt my own personal opinion to be in favor of the higher consistency.

"1935 - 2 juice cans water
1/4 of small pound cake
Some nuts and M&M's
The cake was very welcome by then. It appeared almost like a Christmas gift and gave me a small lift in spirits. This item was easy to consume even in the pressure suit.

"0215 - 1 can pineapple juice - suspected that I drank this to have something to do and for a taste change. I was not particularly hungry or thirsty at the time.

"0220 - Dentyne gum - again for diversion.

"0310 - 1 sweet cracker
1 juice can water

"0440 - Other one-half tube chicken

"The food in the isolation test was of more normal type and particular facts were noted as to container methods, etc. The food was adequate both in variety and quantity, and in this test provided a much greater degree of diversion since this was just about the only thing available to be accomplished. I will state that this food was eaten more as snacks rather than as definitely spaced meals."

During this trial period 1750 calories were consumed.

4. Conclusions

Food provided during the Low Pressure Chamber Flight Profile was adequate in quantity, variety, and acceptability. However, a need exists for familiarizing future subjects, prior to flight, with foods or forms of food which are not commonly

eaten. Usually increased acceptability will occur with increased familiarity. Data again indicate the emotional and social role of food in situations of stress.

D. MANHIGH III BALLOON FLIGHT

1. Introduction

Experience gained from the simulated balloon flight described in section C permitted provision of a suitable means of sustenance for the subject of the MANHIGH flight. Only minor changes based on subjective food preferences, were necessary.

2. Procedure

Foods suitable for consumption in the sealed capsule of the MANHIGH III flight were provided by the Aero Medical Laboratory. An inventory of these, along with accessory items, are included in Table V. Table VI cites the calculated nutritional value of the food as provided. Instructions for preparation of the high protein drink were submitted to project personnel. Consumption of eight ounces of this beverage was recommended during the period of preliminary preparation prior to take-off.

3. Results and Discussion

Food consumed, and its acceptability is again best recorded by direct quotation of the subject:

"On the MANHIGH flight the items consumed are few for two main reasons. First, the flight was cut short, and second, the pressure and pleasure of being launched provided almost complete diversion so that at about 1130 on 8 October (the day of the flight), I realized that I had overextended myself both in food and water requirements. Most of the food consumed on the flight was consumed shortly thereafter. As far as I know, only one can of orange juice was taken before this, and this juice was taken about 0420, before launch.

"The following is the food consumed:

2 cans orange juice
2 cans pineapple juice
1 tube AF chicken
2 chocolate Oreo cookies
3 pounds of water

TABLE V

MANHIGH III BALLOON TRIAL
INVENTORY OF FOOD AND ACCESSORY ITEMS

Food	Unit	Amount Provided
<u>Beverages</u>		
*Chocolate Drink	8 oz bottle	2
Toddy	8 oz can	2
<u>Candy</u>		
Chewing gum	Package	1
Life Savers	Package	1
M&M's	2 oz package	1
<u>Cake, Cookies</u>		
Chocolate Oreos	Package of 4	2
Fruit Cake	2 oz carton	1
Pound Cake	1-1/2 oz carton	1
Sugar Wafers	Package of 6	2
<u>Fruit and Fruit Juice</u>		
Applesauce	3-1/2 oz tube	1
Raisins	1-1/2 oz carton	1
Orange Juice	5-1/2 oz can	4
Pineapple Juice	6 oz can	3
Vegetable Juice	3-1/2 oz tube	2
<u>Meat</u>		
Beef Cubes	Individual package	10
Beef, Semi-solid	3-1/2 oz tube	2
Chicken, semi-solid	3-1/2 oz tube	2
<u>Nuts</u>		
Assorted Nuts	5 oz package	1
<u>Accessory Items</u>		
Can opener		1
Napkins	Individual	8
Straws	Individual	8
Wash n Dri	Packets	6

* A high protein beverage prepared with Sustagen

TABLE VI

MANHIGH III BALLOON FLIGHT
NUTRITIONAL VALUE OF FOOD AS PROVIDED*

	Calories	Protein gms	Fat gms	Carbohydrate gms	Calcium mg	Iron mg	Vit A I. U.	Thiamin mcg	Riboflavin mcg	Niacin mg	Ascorbic Acid mg
Food as Provided for 48-hr Period	5,685	207	243	708	2,609	27.7	5,175	4,541	4,224	34.2	422
Food as Provided Per Day	2,842	103	121	354	1,304	13.8	2,587	2,271	2,112	17.1	111
Recommended** Allowances	3,000	70	-	-	800	12.0	5,000	1,600	1,600	16.0	75

* Values obtained from Food Values of Portions Commonly Used, 8th Edition, A. DePlanter Bowes and C. F. Church, 1956.

**Recommended Dietary Allowances, Revised 1958. National Academy of Sciences, National Research Council, Publication 589.

"The only comment on this was again that the consistency of the chicken was a little too light for my own taste. This is a personal point and, of course, could be reversed with another individual.

"One overall point might be that some method might be developed to provide liquid containers as rugged as the cans but which are able to be reduced easily to small volume for storage as that which has been accomplished with tube foods. An alternate might be to provide a good method of compression of the can after use. I did try to crush these cans which helped to reduce them to storable size, but a great further reduction was, of course, still possible."

Only 600 calories were consumed in flight. The untimely termination of the flight was precipitated by failure of the capsule's heating system. This condition imposed severe heat stress and dehydration. These conditions demonstrated a necessity for systematic feeding, both during the preliminary period of preparation, and during the flight itself. The possibility of extreme stress arising suddenly and unexpectedly during flight suggests the need for scheduled consumption of food during all phases of unusually demanding missions. Permitting the pilot to regulate intake according to personal desire for food and fluids may mean that an emergency can arise when the subject's hydration and nutritional status are already inadequate.

4. Conclusion

Data, though inconclusive, indicate that food and liquid requirements can be met during high altitude balloon flights. However, limited storage facilities create a need for packaging liquids in more suitable containers. Containers when emptied should be easily compressed and reduced in size. In addition, an organized feeding program, both prior to and during flight, should be mandatory. Such a requirement is based on maintenance of an optimal physiological state at all times.

APPENDIX A

LOW RESIDUE DIET

Recommended for Use Prior to Flight Requiring Use of Pressure Suit Assembly

I. OBJECTIVE

Consumption of a low residue diet for 72 hours prior to a flight which requires the use of the pressure suit assembly is recommended to eliminate the urge for defecation. In order to provide foods which will be completely absorbed from the gastro-intestinal tract thereby leaving little or no bulk for the formation of feces, a high protein low residue diet is required. The basis for such a diet is meat, rice, eggs, sugar, small amounts of fruit juices, tea, and coffee.

a. Foods Allowed

Beverages: Carbonated beverages, coffee, tea

Bread: White (toasted or plain), soda crackers

Cereals: Rice, cream of wheat, noodles, macaroni

Cheese: Cottage cheese

Desserts: Gelatin, sherberts, angel food cake, sponge cake, sugar cookies

Eggs: Soft or hard cooked, scrambled, poached

Fat: Butter or margarine, not to exceed 3 tablespoons per day

Fruit: Strained fruit juices, canned peeled fruit, such as peaches or pears in limited amounts

Meat-Fowl-Fish: Beef, liver, chicken, fish

Soup: Clear broth flavored with rice or noodles

Sweets: Sugar, jelly, in limited amounts

Vegetables: Strained vegetables such as tomatoes, peas, carrots, (not more than one serving per day); potatoes (baked or boiled),

b. *Foods to Avoid*

Coarse or whole grain breads and cereals

Cheese, other than cottage cheese

Rich desserts

Fat in excess of 3 tablespoons

Fried foods

Fruits except strained fruit juice and canned peeled fruit such as peaches or pears

Milk*

Tough cuts of meats

Spices, condiments, highly seasoned foods

Sugar and sweets in excess

Vegetables except strained vegetables such as tomatoes, peas, carrots, and baked or boiled potatoes.

c. Recommended Low Residue Menus

	Menu 3rd Day Prior to Flight	Amount
Breakfast	Orange Juice	4 oz
	Cream of Wheat	1/2 cup cooked
	Sugar	1-2 tsp
	Cinnamon or Nutmeg	few grains
	Scrambled Eggs	2
	Crisp Bacon	2-3 slices
	Toast (white bread)	1-2 slices
	Butter	2 tsps
	Strawberry Jelly	1 Tbsp
	Coffee - Cream - Sugar	--
Lunch	Chicken Rice Soup	1 cup
	Hamburger Pattie	3-4 oz
	Baked Potato (no skin)	1 medium
	Cottage Cheese	2 rounded Tbsps
	Bread	1-2 slices

* Milk is a high residue food and should not be used in food preparation or consumed as a beverage.

Lunch (cont'd)

	Butter	2 tsps
	Apple butter	1 Tbsp
	Sliced Peaches (canned)	1/2 cup
	Coffee or tea - cream - sugar	--
Dinner	Tomato Juice	4 oz
	Baked Chicken Breast	4-5 oz raw
	Steamed Rice	1 cup
	Pureed Peas	1/2 cup
	Bread (white)	1-2 slices
	Butter	2 tsps
	Lemon Sherbert	3/4 cup
	Sugar Cookies	2-3
	Coffee or tea - cream - sugar	--

Menu 2nd Day Prior to Flight

Breakfast	Orange Juice	4 oz
	Cream of Rice	1/2 cup cooked
	Sugar	1-2 tsp
	Cinnamon or Nutmeg	few grains
	Soft Cooked Eggs	2
	Crisp Bacon	2-3 slices
	Toast (white bread)	1-2 slices
	Butter	2 tsps
	Grape Jelly	1 Tbsp
	Coffee - cream - sugar	--
Lunch	Pineapple Juice	4 oz
	Broiled Liver	3-4 oz raw
	Buttered Noodles	1 cup
	Tomatoes (stewed and pureed)	1/2 cup
	Bread, white	1-2 slices
	Butter	2 tsps
	Canned Pears	2 halves
	Coffee or Tea - cream - sugar	---
Dinner	Beef Consomme	1 cup
	Broiled Sirloin Steak (lean, no gravy)	4-5 oz, raw
	Baked Potato (no skin)	1 medium
	Cottage Cheese	2 rounded Tbsp
	Melba Toast	2 slices
	Buttor	2 tsps
	Angel Food Cake w/Lemon Sauce	2 oz piece w/ 1/3 cup sauce
	Coffee or Tea - cream - sugar	--

Menu 1st Day Prior to Flight

Breakfast	Orange Juice	4 oz
	Cream of Wheat	1/2 cup cooked
	Sugar	1/2 tsps
	Cinnamon or Nutmeg	few grains
	Hard Cooked Eggs	2
	Crisp Bacon	2-3 slices
	Toast (white bread)	1-2 slices
	Butter	2 tsps
	Coffee - cream - sugar	--
Lunch	Apple Juice	4 oz
	Baked Halibut	3-4 oz raw
	Parsley Potatoes	1 medium
	Hard Roll	1
	Butter	2 tsps
	Cottage Cheese	2 rounded Tbsp
	Strawberry Jello w/Whipped Cream	1/2 cup plus 2 Tbsp cream
	Coffee or Tea - cream - sugar	--
Dinner	Chicken Noodle Soup	1 cup
	Roast Beef (lean without gravy)	4 oz
	Steamed Rice	1 cup
	Sliced Canned Peaches	1/2 cup
	Toast (white bread)	1-2 slices
	Butter	2 tsps
	Orange Sherbert w/Sponge Cake	3/4 cup w/2 oz of cake
	Coffee or Tea - cream - sugar	--

Menu for Morning of Flight

Orange Juice	4 oz
Sirloin Steak (lean)	4-5 oz raw
Scrambled Eggs	2
Toast	2 slices
Butter	2 tsps
Strawberry Jelly	1 Tbsp
Coffee - cream - sugar	--

d. All preflight feeding should occur at a controlled dining facility, preferably one at the Base Hospital where the preparation of special diets is a routine activity. Between meal snacks other than carbonated beverages, coffee, tea, or clear soups, should be avoided.

d. It is desirable that crews be maintained in a state of water balance. The recommended preflight diet provides liberal amounts of liquids and beverages. Carbonated beverages such as Coca Cola, gingerale, 7-UP, tea, coffee, and clear soups are permissable between meals. It is strongly recommended that no alcoholic beverages be consumed during the 24-hour period prior to flight. This recommendation is based on the dehydrating effects of alcohol.

e. Subjects participating in this program should be apprised of the objectives and need for controlled feeding.

APPENDIX B

COMPOSITION AND METHOD OF PREPARATION OF HIGH PROTEIN BEVERAGES

Coffee Drink - 2/3 cup Sustagen*
2/3 cup cold water
1/3 cup coffee, strong
1/2 tsp vanilla

Combine coffee, water and vanilla. Add Sustagen. Mix well. Chill before serving.

Chocolate Drink - 2/3 cup Sustagen*
2/3 cup cold water
1/3 cup chocolate milk
1/2 tsp vanilla

Combine chocolate milk, water, and vanilla. Add Sustagen. Mix well. Chill before serving.

* Sustagen produced by Mead Johnson and Company, Evansville, Ind.

APPENDIX C

NUTRITIONAL VALUE OF HIGH PROTEIN BEVERAGES*

Food	Weight gms	Calories	Protein gms	Fat gms	Carbohydrate gms	Calcium mg	Iron mg	Vit A I. U.	Thiamin mcg	Riboflavin mcg	Niacin mg	Ascorbic Acid mg
Coffee Drink	240	390	23.5	3.3	66.6	700	1.7	555	1,100	1,000	4.5	33
Chocolate Drink	240	450	26.1	5.3	75.4	790	1.7	631	1,126	1,233	4.6	33

* Prepared with Sustagen - produced by Mead Johnson and Company, Evansville, Ind.

CHAPTER XII

PHOTOGRAPHIC EQUIPMENT*

A. INTRODUCTION

The following is a list of photographic equipment, experiments and special problems encountered on the MANHIGH III flight.

1. A method of photographing the subject, and certain areas of the capsule, without effecting the subject's night vision, was a requirement. Two Praktina cameras with infrared film and filters and electronic flash, proved satisfactory for this purpose.

2. A standard Photo Research Inc., spot photometer, equipped with a Robot camera was utilized to take pictures and sky brightness readings simultaneously.

3. A K-100 Eastman-Kodak motion picture camera, with a removable revolving filter wheel which contained red, green, orange, yellow and neutral density filters, loaded with experimental black and white film, was utilized in photographing the horizon and the ground. The same camera, with the filter wheel removed, was used for color motion picture photography at the subject's discretion.

4. Two modified K-100s mounted on the capsule landing gear, were used to photograph the ground and the balloon simultaneously, and at intervals to record rotation and oscillation.

5. A Star Track camera was mounted on the outer side of the capsule to record rotation and oscillation during the night.

6. A Hasselblad camera, and three magazines, were to be used at hourly intervals taking three pictures at different exposures, of the cardinal headings and the ground during daylight hours with color film. The same camera was to be used with a high speed black and white film to photograph certain constellations at night.

7. Two film packs and one cosmic plate (phosphor between thin sheets of glass) were used to record any fluorescence occurring from cosmic hits.

* By T/Sgt F. E. Hensley

B. PROCEDURES AND TECHNIQUES

1. Praktina Cameras

Because of the disruption of night vision by the flash of the photo panel camera during previous flights, it was deemed necessary to provide a means of photography utilizing an invisible portion of the spectrum for exposure.

The use of ultraviolet light was tested first, since Air Force flight instruments are fluorescent. The power drain for this method proved excessive and part of the required equipment produced heat in great amounts. Exposure would have to be re-adjusted during the daylight hours to prevent overexposure. This system would not photograph the subject during the hours of darkness.

Eastman Kodak High Speed Infrared (HIR408) was tested previous to the flight. An electronic flash of 120 watt second output was covered with an 87C filter. The light transmitted through the filter was barely discernible, for the duration of the flash (1/1000th of a second), and did not affect the subject's night vision. Further tests were run with an 89B filter over the lens. This provided sufficient light to use the same exposure for night and day.

The two Praktina cameras, equipped with 50 foot magazines, (loaded with HIR408), electric motors, and release solenoids, were mounted on brackets inside the upper hemisphere of the capsule (Fig. 53). Ring-type "Ascor Lights" (electronic flash) were covered with 87C filter material and mounted above the cameras. This type of light provides very flat lighting to avoid hot spots or flares from shiny surfaces. A sheet of 89B filter material was placed over the 28mm Angenieux lens. The camera mounted behind the subject covered the flight instruments, $p^{O}2$ and humidity instruments. The other camera was mounted on the opposite side of the capsule to record the head and shoulders of the subject. An exposure of f-8 at 1/25th of a second was used. The film was processed in D-76 at 68°F for 20 minutes. This included the 25 percent over-development recommended for this type of photography. The cameras were controlled by the intervalometer located in the electronics section of the capsule. Two intervals were provided - two minutes and six minutes. The short interval was intended for ascent and descent. The cameras were timed so that the flash from the instrument camera would not fog the film in subject camera, and vice versa.

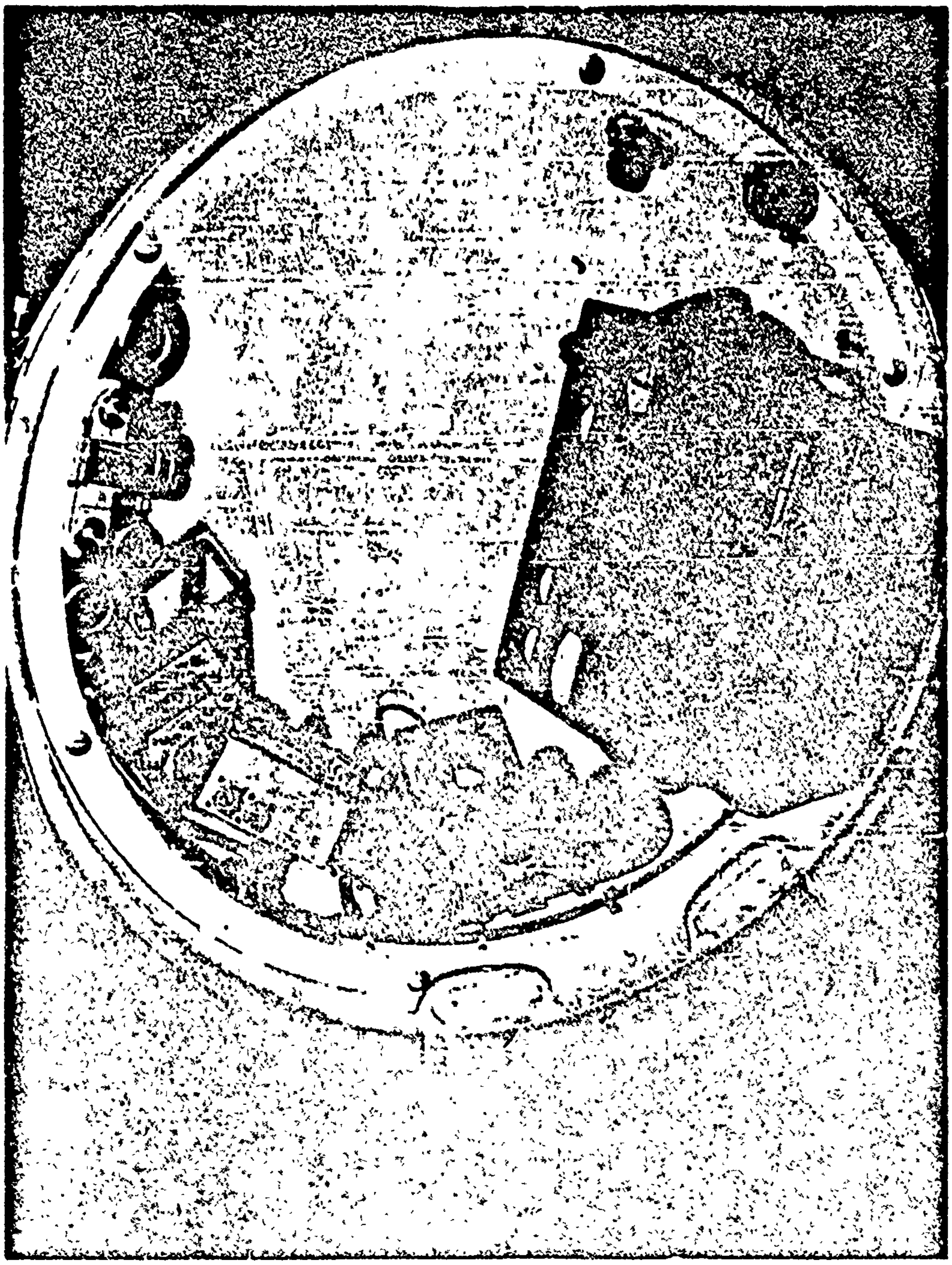


Figure 53. Two Praktina Cameras Mounted on Brackets Inside the Upper Hemisphere of the Capsule

2. Spot Photometer

The Spot Photometer is a standard Photo Research Inc., instrument, modified with the addition of a Bausch and Lomb Interference Wedge for continuous spectral filter selection over the visible region, (4000 to 7000A). A spring operated Robot camera was attached to the photometer with a mechanical linkage so pictures could be taken simultaneously with light readings. The camera could be disconnected if pictures were not necessary. An Abney Level and a Devil Level were attached to accurately measure angles of both photography and readings. Thirty-five mm Super Anscochrome Film was provided in 36 exposure cassettes. Only one of the several sessions scheduled for use of the photometer was completed during the flight. Readings in photopic blue and red filter ranges were taken at elevations 15 degrees above the tangent level and 15 degrees below the tangent. A Spectra computor was furnished with the photometer to convert photometer readings to photographic exposure.

3. K-100 Filter Wheel - Black and White and Color Photography

The K-100 camera equipped with a removable filter wheel and Devil Level was provided by Eastman Kodak Company. An experimental black and white film was to be exposed through each filter at specified times and directions. The same camera, with the filter wheel removed, was used for color motion picture photography at the subject's discretion. Ten rolls of Anscochrome film was provided for this purpose.

4. Hasselblad Camera and Magazines

This standard single lens reflex camera was equipped with a metal mirror mounted at a 45 degree angle above the ground glass to facilitate focussing and viewing. This is necessary to properly use the camera through the portholes and to permit the subject to move effectively and use the camera when wearing the partial-pressure suit.

The three magazines were provided to enable the subject to accomplish the hourly programmed photography without stopping to reload. Three color photographs were to be made of the cardinal headings every hour. One frame was to be exposed according to the Weston Meter reading and the other frames taken a stop above and a stop below the normal reading. Three more pictures were to be taken of the ground in the same manner. Any unusual phenomena would be photographed at the subject's discretion. Twenty rolls of Anscochrome color film and two rolls of Ansco Super Hypan were provided. The camera was to be used during the

night to photograph selected star field areas (Super Hypan predetermined exposure at one second and f-2.8), and to obtain very under-exposed photographs of the setting sun - under-exposed deliberately to delineate the bright solar disk.

5. K-100 Up and Down Cameras

The two K-100 cameras were mounted on the landing gear of the capsule. They had been previously modified for single frame exposure, provided with a tripping solenoid, and an electric motor to wind the spring. The two cameras and one battery were inclosed in a standard styrofoam package. Plastic water bottles were provided to warm the battery (Fig. 54).

A 5.3mm 84 degree lens was used on the "up" camera and a 25mm lens on the "down" camera. UV-17 filters were used on both lenses. Simultaneous exposures were controlled by the photo intervalometer inside the capsule. The cameras were loaded with Kodachrome film. The exposure was 1/20th at f-11. Simultaneous photographs were to be taken of the balloon and the ground. Both oscillation and rotation would therefore be recorded.

6. The Star Track Camera

The Star Track camera was attached to the outside of the capsule and was a modified identification-type camera. The film would move continuously, once started. No shutter was utilized. A high speed black and white film was used. The camera, timer and battery were packaged in styrofoam and formed a self-contained unit. The timer was set to start the camera after dark, and would record oscillation and rotation during the night (Fig. 55).

7. Cosmic Ray Experiment

A special plate was made with two thin pieces of glass with a phosphor layer between. This was placed between two 2-1/4 by 3-1/4 inch Tri-X film packs with the edges sealed to prevent the film being struck by light. When the protective tab was removed from each pack, the film would be in contact with both sides of the phosphor-"sandwich". The time each sheet of film was in contact with the plate was to be recorded. Utilizing film packs for this experiment permitted 12 different exposures on each side. It was expected that cosmic hits would cause sufficient fluorescence to be recorded on the film.

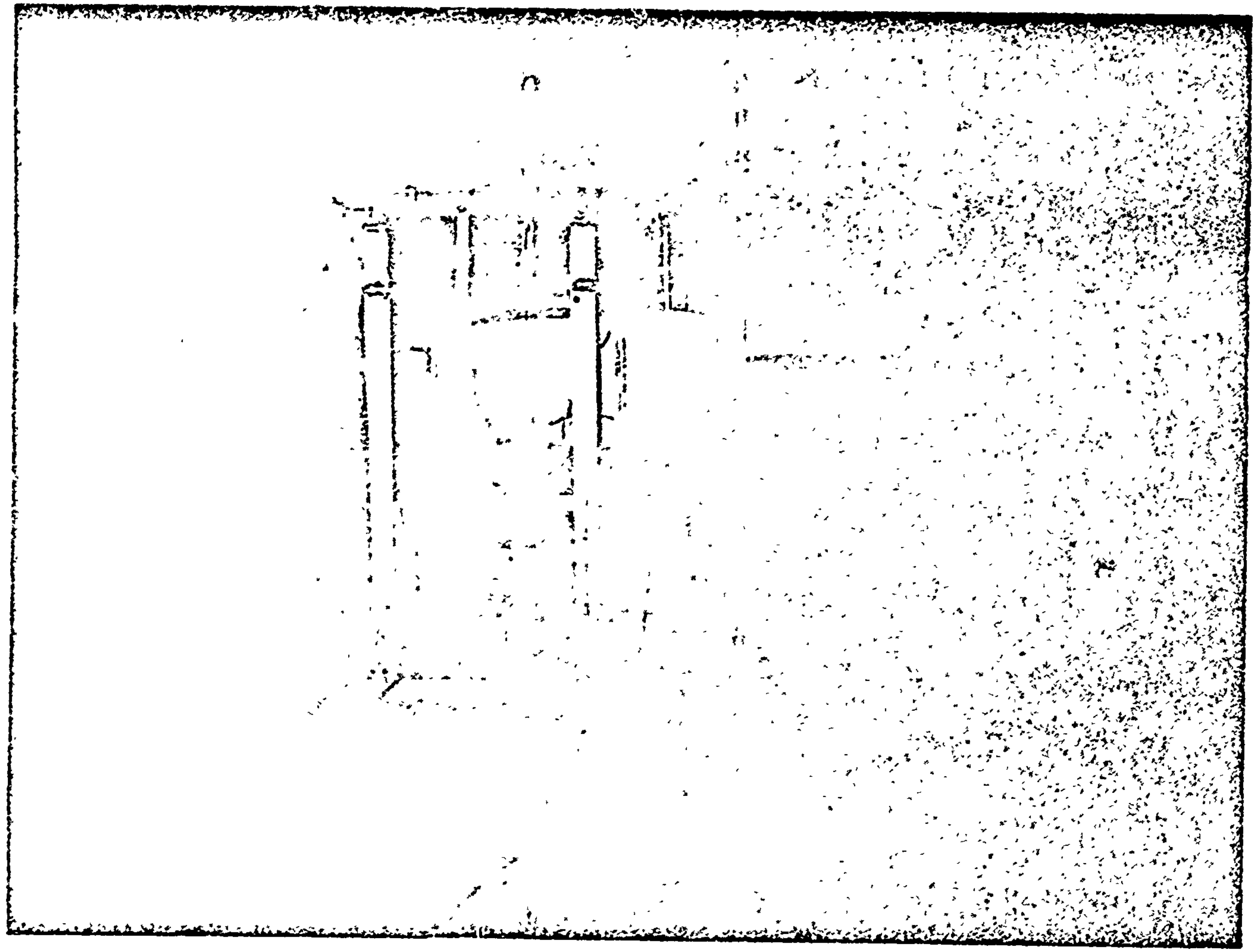


Figure 54. Two K-100 Cameras and a Battery Inclosed in a Standard Styrofoam Package

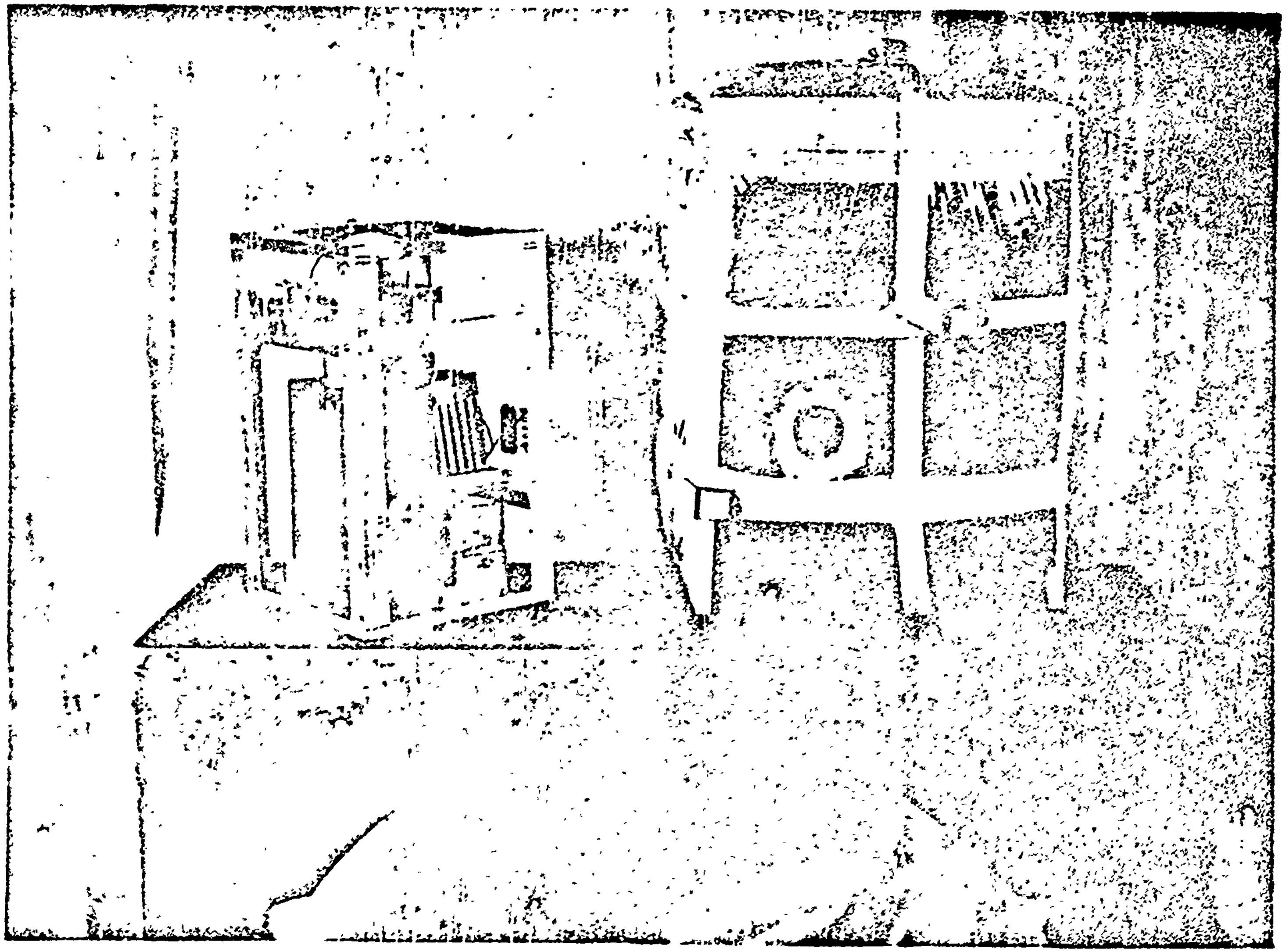


Figure 55. The Star Track Camera, A Timer and a Battery Packaged in Styrofoam Forming a Self-Contained Unit

C. RESULTS

1. Praktina Cameras

Both cameras operated intermittently during the flight. Considerable heat fogging occurred in both cameras. The film in the photo panel camera fogged the most. This camera was located about one-eighth inch above the ventilation ring in the upper hemisphere of the capsule. Fogging was caused by the warm air from the air regeneration system that flows through the ventilation ring. The film was approximately 50 percent usable. The negative density was heavy because of the fogging.

2. Spot Photometer

Photographs were not obtained during the taking of light readings because of a malfunction of the mechanical linkage between the photometer and the Robot camera.

Readings obtained with the spot photometer were submitted to Scripps Oceaneographic Institute for evaluation.

3. K-100 Filter Wheel - Black and White and Color Photography

The experiment with the filter wheel and black and white film was not accomplished.

Two rolls of 16mm Anscochrome film were exposed during ascent and at ceiling. The footage exposed utilizing the down mirror is very good and shows both rotation and oscillation. The ground detail is excellent, especially during ascent over the mountains. The footage taken toward the horizon tends to be over-exposed. Footage taken from the horizon up was satisfactory.

4. Hasselblad Camera

Five rolls of Anscochrome film were exposed. Pictures taken through the capsule up mirror of the balloon were excellent. Pictures taken toward the horizon are over exposed. The only usable photographs were the stopped down portion of the quadrant picture series. These were one stop less than the exposure indicated by the Weston Light Meter reading, and even some of these exposures were light and not fully color saturated.

5. K-100 Up and Down Cameras

Both cameras operated intermittently during the flight, but skipped frames because of malfunction of the photo intervalometer; also, the shutter remained open at times. Approximately

40 feet of film was exposed. The exposure is excellent on the film from the "up" camera. Film from the "down" camera was usable but is slightly under exposed at the beginning of the flight and slightly over exposed while the capsule was over light colored terrain. The ground detail was good.

6. Star Track Camera

No data were available from this camera because of the early termination of the flight.

7. Cosmic Ray Experiment

Film packs were released to Dr. H. Yagoda. The results are included in Chapter IX.

D. DISCUSSION AND RECOMMENDATIONS

1. Praktina Cameras

Cameras using infrared film should be mounted as far as possible from heat or any high intensity infrared sources. The power supply should be as near the camera as possible and protected against low temperatures. A positive mechanical intervalometer, not effected by cold, heat, or pressure conditions should be used. The intervalometer used for the MANHIGH III flight continually malfunctioned under low temperature and pressure conditions, yet operated perfectly under normal ground conditions.

2. Spot Photometer

A more positive mechanical linkage should be designed if the photometer is to be used in conjunction with a camera. A means of mounting the photometer on an arm and tripod head should be added so it need not be supported manually by the subject. The instrument was much too heavy, cumbersome and awkward to be operated efficiently in a confined space.

However, the photometer gave readings of a very narrow field of 1-1/2 degrees and the readings were readily converted to photographic exposures. Use of this permits the subject to take light readings of relatively small areas and obtain a correct exposure of that area.

The Weston light meter gave headings of much too wide a field, usually 67 degrees horizontal and 55 degrees vertical. This type of meter must be held at an angle so none of the sky is included if correct exposures of the ground are to be made.

3. K-100 Filter Wheel - Black and White and Color Photography

A camera equipped with an automatic exposure control would simplify motion picture photography, and would give better overall exposure control. Scenes covering the ground and sky in one frame would still tend to be over exposed. A telephoto lens and matching exposure control would help regulate this condition, but would cover a much smaller area. Exposure, otherwise, should be computed for the brightest portion of the scene being photographed.

4. Hasselblad Camera

Specific areas should be framed as much as possible for each exposure. If both the ground and the sky are being photographed at the same time, the exposure should be computed for only the brightest area. Again, a means of reading light intensity of small areas is needed to produce perfect exposures of certain selected areas.

5. K-100 Up and Down Cameras

Automatic exposure control would be helpful on the "down" camera. Otherwise, a mechanical control could be provided to be operated by the subject to compensate for changing light conditions. The predetermined exposure seems satisfactory for the "up" camera. A reliable intervalometer should be provided.

6. Further Recommendations

More importance should be attached to photographic functions on future flights. Also, a sufficient amount of time should be allotted to the subjects to familiarize themselves with the photographic equipment before the flight.

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